

Property of  
Lake and River Enhancement Section  
Division of Fish and Wildlife/IDNR  
402 W. Washington Street, W-273  
Indianapolis, IN 46204

**Lake Lemon Lake Enhancement Project  
Biotechnical Shoreline Stabilization Project**

**Draft Design Report**

for the

**Lake Lemon Conservancy District**

sponsored by the

**Lake Lemon Conservancy District,  
the City of Bloomington Utilities**

and the

**Indiana Department of Natural Resources,  
Division of Soil Conservation**

**June, 1997**

by

***COMMONWEALTH BIOMONITORING, INC.***



## Table of Contents Design Report

<u>Section</u>	<u>Content</u>
1.	Specific location with legal description of project.
2.	Overall description of design project.
3.	Objective of project design.
4.	Hydrology and hydraulics, where applicable the following information will be provided:
a.	Assumptions.
b.	Models and programs used.
c.	Criteria, design limitations.
d.	Brief narrative description of design results.
5.	Stability Analysis.
a.	For embankments, foundations, emergency spillways, channels (where applicable), based on standard analysis methods, including:
	- Assumptions.
	- Criteria.
	- Brief narrative description of resulting design.
6.	Structures.
a.	Assumptions.
b.	Criteria.
c.	Brief narrative description of resulting design.
7.	Environmental concerns (mitigation where applicable).
8.	Land rights needed, including permanent and/or temporary flood easements.
9.	Special items, or materials required including plant lists and planting guides where applicable.
10.	O&M considerations that have affected design.
11.	Engineer's estimate by bid item.
12.	Applicable environmental permits.
13.	Engineer's estimate for engineering and inspection services during project construction phase.

# **Section 1**

**Specific location with legal description of project.**

## **Section 1. Specific Project Locations**

For a map of site locations refer to Sheet 2 of the plan set.

Site 1A-1 is owned by the City of Bloomington Utilities located in the northwest corner of Lake Lemon.

Site 1C is the north side of north Cemetery Island and is owned by the City of Bloomington Utilities.

Site 3B is owned by the Lake Lemon conservancy District.

Due to the fact that the sites are all located wholly on property owned by the sponsoring entities Lake Lemon Conservancy District and the City of Bloomington utilities, it is deemed unnecessary to obtain legal descriptions of the properties for the benefit of the contractor.

Ingress/egress access to each of the sites is on land owned by the sponsoring entities.

## **Section 2**

**Overall description of design project**

# **LAKE LEMON BIOTECHNICAL SHORELINE STABILIZATION DESIGN PROJECT**

## **Section 2     Overall Project Description**

This is a brief synthesis of the Lake Lemon Shoreline Biotechnical Stabilization Feasibility Study that presents targeted sites, design and construction constraints, recommended construction techniques, and estimated construction costs.

### **2A.     Targeted Sites**

Table 1 presents:

- A description of the individual identified sites within each general project area in need of treatment,
- the ownership of each site,
- the measured length of shoreline that needs to be treated at each site,
- relative severity of erosion for each site,
- the relative ease of access,
- the recommended alternative from the Exhibits in Appendix A with the estimated treatment costs from the Attachments in Appendix B.

Exhibit 1 (Sheet 2 of 13) is a map depicting the locations of the targeted sites.

**Table 1**  
**Lake Lemon Measured Shoreline Areas, Severity, Ownership, and Access**

Long East/West Fetch Sites Area 1	Ownership Public/Private	Linear Feet Of Treatment Needed	Relative Severity of Site Erosion	Relative Ease of Access
Area 1a. West end of lake n. of spillway. Priority 2 Site	CBU - Public	150' and 320'	Extreme (150')	Good - some improvement needed
Area 1b. pt. between dam and spillway. Priority 9 Site	CBU - Public	540'	Severe - field checked - slight upland sloughing*	Good - some improvement needed
Area 1c. Island Priority 3 Site	CBU - Public	200' (more less severe erosion)	Severe	Poor - boat only hand placed revetment**
South Shore Category 1 Sites Area 2	Ownership Public/Private	Linear Feet Of Treatment Needed	Relative Severity of Site Erosion	Relative Ease of Access
Area 2a. Riddle Point Beach Priority 7 Site	CBU - Public	265'	Extreme	Excellent
Area 2b. Riddle Pt. former campground Priority 4 Site	CBU - Public	445'	Severe	Excellent
Area 2c. Boys/Girls Club Priority 6 Site	CBU - Public	235'	Extreme	Excellent
North Shore Category 1 Sites Area 3	Ownership Public/Private	Linear Feet Of Treatment Needed	Relative Severity of Site Erosion	Relative Ease of Access
Area 3a. - West side of Reid Point. Priority 1 site	Private and CBU	444'	Extreme	Good - road needs improvement
Area 3b. Alternate Site LLC property Priority 5 Site	CBU - Public	270'	Severe	Good - New LLC Road
Area 3c. E. end of Dettemer Rd. Priority 8 Site	CBU - Public maybe some Private	460'	Severe	Good Access from Dettemer Rd.
	Total Linear Ft. Planned for LARE Project Treatment	2,829 L.F. Total	914' Extreme 1,915' Severe	Total Est. Costs = \$377,550

\*\* = Poor access may require hand placement of revetment at additional cost.

Note: Exhibit 3 is a rip rap conceptual design, and Exhibit 4 is a gabion mattress conceptual design.

## **2B. Description of Treatment Strategies**

The planned cut and fill excavation to reduce the shoreline slopes to a maximum of 2H:1V si balanced in most shoreline areas to minimize the amount of soil to import or spoil to dispose of. The preferred method of bank excavation to reduce slope gradient is to begin the cut from the top of the slope cutting downward, thereby extending the toe of the slope outward. Because obtaining permits to place fill in the lake bed may be difficult, cutting from the top of bank to extend the toe of the slope lake ward is minimized in construction plans. In order to save most existing shoreline trees it is imperative that some areas of bank be extended lake ward.

The lake level should be maintained at least three (3) feet below normal pool, if possible, for proper excavation, placement of fill, compaction, and construction period sediment control.

## **2C. Environmental Constraints - Lake shore Tree Preservation**

Along the targeted shoreline is a variety of existing wildlife habitats. There are several down trees and drift logs, that are along the Lake Lemon banks which provide cover for a variety of aquatic and terrestrial/aquatic wildlife.

Several large trees along the shoreline are standing at the top of the bank. Some are leaning presenting a wind throw hazard. Some of these trees are used as perches for the resident and migratory bald eagles at Lake Lemon.

Most of the trees at the top of the banks do not pose a wind throw hazard and should be preserved for the soil matrix binding of their root systems. In addition, it is anticipated that adjacent landowners would oppose the removal of these trees. The existing trees add value to the adjacent properties by providing shaded recreation areas and wind protection.

## **2D. Lake Level Control Limitations**

The construction project is planned to be conducted with the lake level drawn down at least 3.5 feet below normal pool elevation of 630'. Given the small diameter (48") of the outlet structure and the large size of the Lake Lemon watershed ( 70 square miles) it is the understanding of Commonwealth Biomonitoring Inc. staff that the Lake Lemon water level may not be controlled substantially below normal pool level with a great degree of certainty.

Since the outlet structure may not be large enough to accomplish this with certainty, the construction method must be to work from the top of the banks with reaching equipment to dress the slope lightly, remove smaller, movable debris, and to place rip rap.

## **2E. Debris/Drift Removal**

To gain access to the shoreline and to prepare the sites for slope dressing and placement of flexible revetment, it will be necessary to remove some existing drift and debris from the shoreline. The drift should be moved lake ward from the shoreline to provide fish habitat and a wave buffer.

The contractor can move some drift and debris with a reaching bucket from the top of the bank to make way for geofabric and rip rap. Therefore, the shoreline stabilization flexible revetment (rip rap) must be installed around the larger drift and logs that cannot be moved lake ward from the top of the bank with reaching equipment.

## **2F.        Construction Access to Targeted Sites**

Site 1c cannot be accessed with land based equipment and will require handling material twice. Many other sites identified in the Feasibility Study are not among the targeted sites in Table E.S. 1 due to poor access.

## **2G.        Summary of Construction Method to be Designed**

Given the anticipated and potential problems associated with bank reduction excavation, the biotechnical lake shore construction project has been designed with a minimum amount of slope reduction excavation.

Flexible revetment will include a heavy geofabric placed beneath locally available rip rap with a mean diameter of 8" placed a minimum of 24" thick.

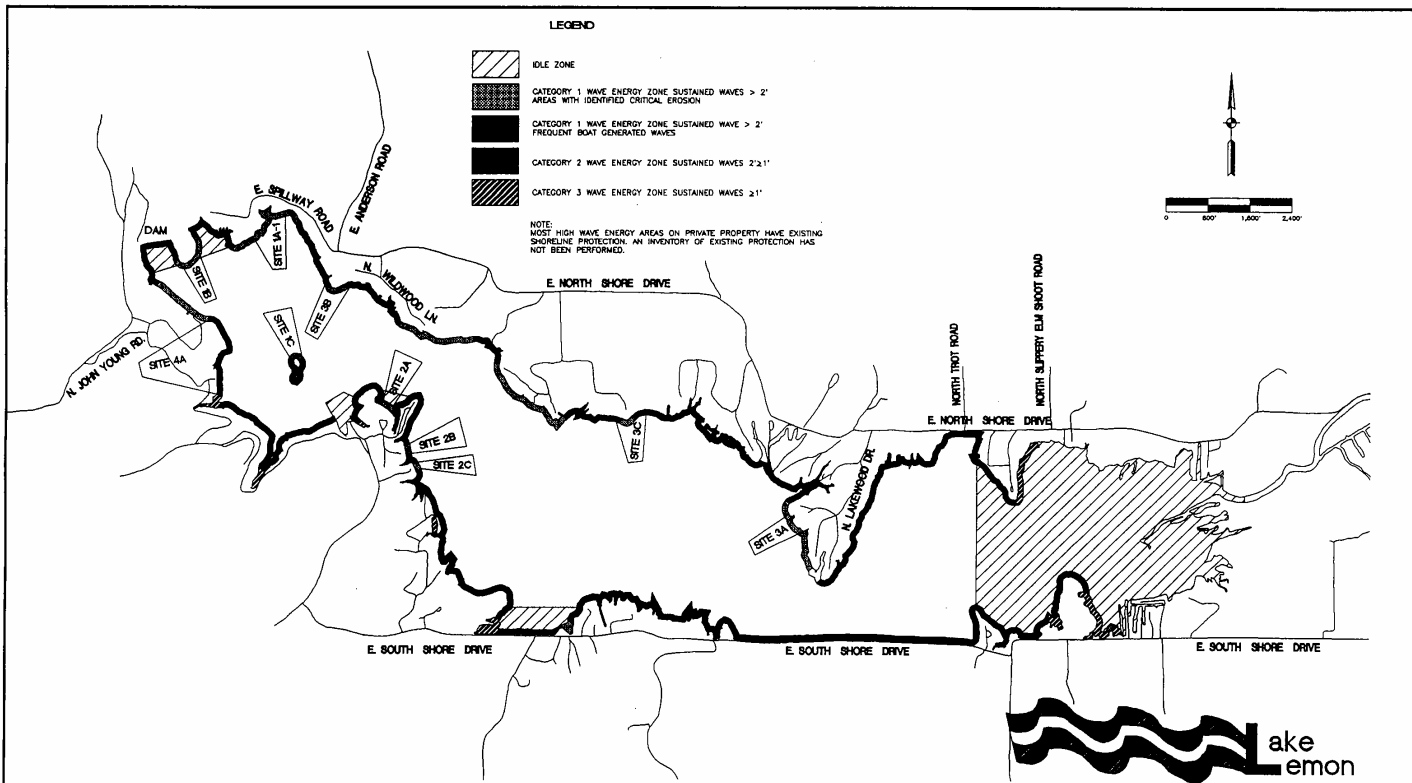
A keyway is to be installed at the toe of the slope that must have a minimum depth of 4' with a minimum bottom width of 2' and side slopes with a maximum slope of 2H:1V.

The smaller trees and logs that can be moved with a back hoe from the top of the bank will be pushed into the lake. Smaller debris that can be moved by hand will also be removed. Larger trees and logs may remain in place with geofabric and rip rap placed snugly around the logs.

Potential wind throw hazard trees may not be pushed over. Rip rap and geofabric must be placed around them. As they fall naturally, the LLCDC will have a limited amount of maintenance to perform in installing geofabric and rip rap as needed to protect newly exposed earth.

The vegetation to be established will be limited to shrubs and trees planted through the geofabric prior to rip rap placement and planted in the upper reaches of the treatment zone. Herbaceous cover tends to be grazed by geese and do not establish well in higher energy zones. Species to be planted will include but not be limited to:

- sandbar willow
- sycamore
- bald cypress
- button bush
- silver maple



7599 N. Tunnel Rd., P.O. Box 59  
Unionville, IN 47468  
Phone (812) 354-0233

**COMMONWEALTH  
BIOMONITORING, INC.**

**COMMONWEALTH  
ENGINEERS, INC.**

DRAWN BY: ITU/BAE  
DESIGNED BY: CWC  
CHECKED BY:  
DATE: JUNE, 1987  
JOB NO.: 8510-01  
SCALE: AS SHOWN

LAKE LEMON  
LAKE ENHANCEMENT PROJECT  
BIOTECHNICAL SHORELINE STABILIZATION  
AREA LOCATION MAP  
AND WAVE ENERGY ZONE MAP

8/10/87 JMS 7285  
DRAWING NO.  
**2**  
2 OF 13

## **Section 3**

**Objective of project design**

## **Section 3      Objectives of Project Design**

### **3a.      Project Objectives**

The overall objectives of the project are to cost effectively stabilize the most critically eroding sites of the Lake Lemon shoreline using a combination of conventional engineered flexible stone revetment (rip rap) and establishment of trees and shrubs to stabilize the banks with root matrices and to alleviate hydrostatic pressure in the slope through evapotranspiration.

### **3b.      Design Considerations**

The following concepts are considered for optimal critical area biotechnical shoreline stabilization design.

- Design wind speed direction and prevailing directions.
- Field inspections of lake shore erosion critical areas.
- The elevations of the maximum wave runup elevations and the toe scour elevations have been calculated to ensure that the flexible revetment covers the 90% high energy zones.
- Structural stability and longevity of flexible revetment features.  
Resistance to hydraulic stress, erosive scour, and wave action.
- Minimization of operation and maintenance costs.
- Minimize construction costs.
- Revegetation of the lake shore through the flexible revetment to add stability and for aesthetic reasons.
- Minimization of erosion that could be introduced to the lake during construction.
- Minimization of excavation time and costs near the lake shore.

## **Section 4**

**Hydrology and hydraulics, where applicable the following information will be provided:**

- a. Assumptions.**
- b. Models and programs used.**
- c. Criteria, design limitations.**
- d. Brief narrative description of design results.**

## **Section 4. Lake Lemon Hydrology and Hydraulics**

### **I. Maximum and Minimum Wave Energy Zones**

Long-term lake level data was not readily available for statistical analysis. Limited data was available to calculate average annual ordinary high water elevations. Ordinary low water elevations were based on locally provided information from observations on low water levels. There was not sufficient lake elevation data available to calculate ten year high and low lake elevations. Lake level data was generated from data provided by the IDNR Division of Soil Conservation and Division of Water.

#### **A. Types of Waves**

There are three basic sources of wave action in freshwater lakes and reservoirs. They are:

1. wind generated waves;
2. boat generated waves;
3. inland lake surges, tides, and seiches.

The last category is negligible in their effects on shoreline erosion, therefore, this project focuses on wind and boat generated waves.

#### **1. Wind Generated Waves**

Most Midwestern inland lake shore stabilization projects use the USDA NRCS method of assuming 50 MPH as the maximum sustained storm wind speed for the Midwest. Given a 50 MPH wind and the fetch lengths at Lake Lemon, the maximum generated wave height is from 3.0 to 3.4 feet (at west side of Reid Point and northwest lake shore north of the spillway) from trough to peak (from USDA, NRCS Indiana Field Office Technical Guide). In most Category 1 shoreline areas of Lake Lemon, the wave generated wave height is overridden, for design purposes, by the boat generated maximum wave heights (3 feet in most areas).

CBI staff performed research to obtain 30 years worth of recorded data on average annual wind speeds and wind direction frequency for central Indiana. The Midwest Climate Data Center was consulted to obtain recorded data on the frequency of wind direction and average annual wind speeds. The prevailing winds are generated from the west south west. This data was used to prioritize eroding shoreline areas in the preliminary engineering study.

#### **2. Boat Generated Wave Heights**

The USDA NRCS Technical Release 2 design manual gives typical maximum boat generated wave data for inland lakes of three (3) feet from trough to peak, or 1.5' above still water level. This assumes a 20' deep draft pleasure boat operated at 20 MPH.

CBI staff also consulted Dave Ison, owner of I&S Marina on the size and type of boats moored on Lake Lemon and the magnitude of waves generated from the larger boats.

Mr. Ison concurred that the estimated maximum boat generated wave heights on Lake Lemon would be three (3) feet, based on his experience and knowledge of the boats presently and historically moored and launched on Lake Lemon.

Therefore, most of the main body lake shore is subjected to boat generated wave action of three feet high or less.

## **B. Wave Runup**

Wave runup is dependent on the slope and surface roughness of each individual site. The steeper a lake shore and smoother its face, the higher waves will run up the bank. Wave runup can be reduced in two ways, by reducing the lake shore slope and by increasing the surface roughness of the slope. Rip rap and planted vegetation are very effective methods to increase the surface roughness of a lake shore. Excavation to reduce soil slopes to a more moderate 2:1 slope was also designed for stability and a reduction in wave runup.

Based on the typical maximum slope of the banks to be treated being 2:1 slope the wave runup factor is 2.3' plus the wave height over water level (1.6' maximum). Since the surface is proposed to be a rough rip rap or live staked vegetated surface the correction factor for roughness is .6 times the wave runup. Table 2 presents the maximum wave runup elevations for the category 1 wave energy zone.

## **C. Lake Levels**

### **1. Sustained Maximum Lake Level Elevation**

The IDNR Division of Soil Conservation provided U.S.G.S. lake level data from 1961 through 1965 and 1967. The U.S.G.S. data is relatively old data but the "best available information." Because Lake Lemon was a water supply reservoir throughout the data period (1961 through 1965 and 1967) the lake level was commonly drawn down for water supply during dry periods. Now that the lake is no longer used as a water supply reservoir the water level is not substantially reduced during dry periods. Therefore, the low water level elevations from the 1961 - '65 and 1967 data set are no longer valid. This was the best available recorded information for the Lake Lemon lake levels. More recent lake level records were not obtainable.

Historical lake level data was the basis for estimating the ordinary high water level. This is the range of elevations between the normal pool elevation and the 99% peak maximum elevation that we could expect the water to be within 3 or more days of any given year.

The survey information provided by the U.S.G.S. gives the spillway crest height at 630' (629.97') and the gage height at 620.1' (620.101') above the 1929 geodesic mean sea level or 9.90' below the spillway crest.

According to historic information, the Lake Lemon spillway is the controlling hydraulic factor when the water level is above the spillway crest. Regardless of withdrawals for

drinking water and evaporation, when the water level was over the spillway, the spillway was the controlling hydraulic factor.

**a. Maximum Peak Lake Levels**

From interviews with long term Lake Lemon residents the marked peak high water level is reported to be from 2.5' to 2.66' feet above normal pool elevation. It is reported that the peak occurs only in very infrequent exceptional conditions (such as a saturated, or frozen watershed soil condition) combined with a 50 to 100 year or more frequency storm event. It is reported that maximum peak is not sustained for greater than 24 hours in any given year, and should not be the maximum design elevation for shoreline protection due to limited funding. Reportedly, the maximum peak occurs far less than 1% of any annual period.

**Table 1**  
**High Water Elevation Data From U.S.G.S. 1961 - 1965 and 1967 Data Set**

Year of Record	Peak Gage Height	Peak Lake Elevation	Avg. of 3 Highest Gage Heights in Year of Record	Avg. of 3 Highest Lake Elevations in Year of Record
1961	10.2'	630.3'	$10.2+10.13+10.02/3=10.12$	630.22'
1962	11.0'	631.1'	$11.0+11.0+10.88/3=10.96$	631.06'
1963	11.72'	631.82'	$11.72+10.92+10.81/3=11.15$	631.15'
1964	11.06'	631.16'	$11.06+10.67+10.67/3=10.8$	630.9'
1965	10.85'	630.95'	$10.85+10.78+10.73/3=10.79$	630.89'
1967	11.70'	631.8'	$11.70+11.40+11.18/3=11.42$	631.52'
Average of 6 years	11.1'	631.2'	10.87'	630.97'

**2. Ordinary Low Water Elevations**

Low water data is less critical from a shoreline stabilization perspective for two reasons. First, the slope from the lake shore lake ward is very gradual (thus stable) 10:1 slope, and second, Lake Lemon is seldom below normal pool elevation. Due to the large watershed size and the relatively small outlet structure (42 inches) that is left half open (to maintain a minimum flow for downstream ecology) the lake level seldom is reduced to below normal pool elevation.

According to local sources, since the outlet structure has been repaired, the Lake Lemon water level has not dropped below .66 feet (8 inches) below normal pool of 630 (629.97 by U.S.G.S. data) feet. Therefore, from locally supplied information, the ordinary low water elevation is estimated at 629.25 feet. With ordinary low water

elevation at 629.25 feet, the base water level elevation for a shoreline stabilization project may be assumed at 629 feet.

**a. Sustained Minimum Lake Levels**

As mentioned earlier Lake Lemon has not been used as a municipal water supply reservoir since the mid 1970's. Primary water losses from the lake are due to evaporation, and flow through a relatively small (42") outlet gate left partially open to provide minimum flows to Bean Blossom Creek below the dam. Within the past year the outlet gate for Lake Lemon was repaired to be operable throughout its open and closed range. In recent years the lake level would be reduced approximately one foot during prolonged dry periods, due to the gate being stuck completely open. Since the outlet structure has been repaired it is anticipated that the water level will remain more constant, however, there is no available recorded data to substantiate what minimum lake levels could be anticipated.

**Table 2 Lake Levels**

Normal Pool Elevation	630 Feet Above Mean Sea Level
Sustained Maximum High Water (24 hour sustained elevation 99%)	631.2 Feet Above Mean Sea Level
Ordinary Low Water Level	629.3 Feet Above Mean Sea Level
Estimated Maximum Sustained Wave Peak Elevation Category 1	632.5 to 632.7 Feet Above Mean Sea Level
Estimated Minimum Sustained Wave Trough Elevation Category 1	627.8 to 627.6 Feet Above Mean Sea Level
Wave Runup 2:1 slope with a surface roughness factor of .6	634.2' Feet Above Mean Sea Level

Therefore the design wave energy zone for category 1 wave energy zone is 629' to 634.5' feet above mean sea level or a 5.5 foot energy zone.

**D. Lake Level Control Limitations**

Given the small diameter (42") of the outlet structure and the large size of the Lake Lemon watershed ( 70 square miles) it is the understanding of Commonwealth Biomonitoring Inc. staff that the Lake Lemon water level cannot be controlled substantially below normal pool level with a great degree of certainty.

If the contractor would be required to reduce lake shore slope by cutting from either direction then the lake level must be maintained at least 3 - 4 feet below normal pool during the construction period. Since the outlet structure is not large enough to accomplish this with certainty, the construction method must be to work from the top of the banks with reaching equipment to dress the slope lightly, remove movable debris, and to place rip rap on the bank with a bermed configuration.



**GEOTECHNICAL EXPLORATION REPORT  
LAKE LEMON SHORELINE STABILIZATION  
PROJECT**

**UNIONVILLE, INDIANA**

**COMMONWEALTH BIOMONITORING, INC.  
INDIANAPOLIS, INDIANA**

**ETS PROJECT NO. I6651  
June 11, 1997**

June 11, 1997



*Geotechnical, Environmental  
& Materials Consultants*

Mr. Steve W. Chafin  
Project Manager  
Commonwealth Biomonitoring, Inc.  
7256 Company Drive  
Indianapolis, IN 46237

Re: Report of Geotechnical Investigation  
Lake Lemon Shoreline Stabilization Project  
Unionville, Indiana  
ETS Project No. I6651

Dear Mr. Chafin:

We have completed the geotechnical investigation for the shoreline erosion protection project for Lake Lemon located in the rural area near Unionville, Indiana. This report presents the results of our site reconnaissance, subsurface exploration, geotechnical evaluation, and recommendations for wave energy absorption revetments.

It has been a pleasure working with you on this project. If you have any questions regarding this report, or require further information, please do not hesitate to contact us.

Respectfully,

**ENGINEERING & TESTING SERVICES, INC.**

A handwritten signature in dark ink, appearing to read "E M Dwyre", with a long horizontal flourish extending to the right.

Elizabeth M. Dwyre, P.E.  
Geotechnical Services Manager

3 pc: Enclosed

## TABLE OF CONTENTS

### EXECUTIVE SUMMARY

<b>1. INTRODUCTION</b>	1
1.1 Introduction	1
1.2 Erosion Site Locations	1
1.3 Project History	1
1.4 Design Wave Information	2
1.5 Proposed Construction	2
1.6 Scope of Services	3
<b>2. PROCEDURES</b>	5
2.1 Site Visit	5
2.2 Subsurface Exploration	5
2.3 Laboratory Testing	6
<b>3. RESULTS</b>	8
3.1 Topography	8
3.2 General Geology	8
3.3 Shoreline Erosion Observations	9
3.4 Soil Conditions	12
<b>4. ANALYSES AND RECOMMENDATIONS</b>	14
4.1 Erosion Evaluation	14
4.2 Erosion Control and Slope Stabilization	15
4.3 Excavation	21
4.4 Future Upland Slope Stabilization	21
4.5 Plan and Specification Review and Quality Control	22
<b>5. GENERAL COMMENTS</b>	23

### APPENDIX

## EXECUTIVE SUMMARY

A summary of the conclusions and recommendations contained in this report is given below. This summary should not be considered apart from the entire text of this report, including all conclusions and qualifications mentioned therein.

ETS performed a geotechnical evaluation for shoreline protection against wave energy at ten sites along the shoreline of Lake Lemon. The erosion sites generally consist of an immediately upland slope of about 4H to 2H : 1V, well covered by vegetation. Shoreline erosion and very steep slopes were generally observed at the toe, as shown in photographs in the Appendix. Slumps or apparent surficial sloughing apparently triggered by erosion at the toe were observed at multiple sites. However, scarps associated with slumps and sloughing generally were within about 3 to 5 feet from the shoreline, except at site 1B where apparent surficial sloughing extended back from the shoreline about 60 feet, and site 3B where there is a large leaning tree with an area of soil about 10 to 15 feet diameter which appears to have rotated toward the lake. The approximate upland and toe slopes, soil type, the approximate maximum height of the eroded slopes, and locations of observed slumps and sloughing are listed in Table 2.1.

Based on the regional geologic mapping, unconsolidated deposits along the shoreline consist of residual soils degraded from the bedrock, or lacustrine deposits consisting of loessial silty clay, silt, silty fine sand with clayey binder of former lake areas. Based on site observations and sampling, the soil conditions encountered on the slopes generally consisted of brown silty clay to clayey silt, and silt with some sand and gravel at the toe of the slope.

Based on the field observation, and the limited sampling and laboratory testing program, we conclude the severe loss of the soil slopes at the toes appears to be caused by wave energy erosion, with weathering by freezing and thawing contributing to the erodibility of the materials.

In general, for the ten subject sites, we anticipate adequate erosion protection for the design wave conditions can be achieved with riprap or gabion revetments, except at sites 1B and 3B. For site 1B, where there is evidence of upland sloughing, additional measures such as drainage may be necessary to reduce the risk of continued slope movement. Additional geotechnical exploration would be necessary to develop detailed recommendations for remedial measures at site 1B. For site 3B, protection of the area of the large leaning tree is not practical without placement of fill in the lake, which we understand is not feasible based on permitting considerations. Therefore, a "do nothing" alternative in the immediate area of the tree may be the most practical alternative. Over time, continued erosion is likely to cause the tree to fall, at which time the area may be graded and slope protection installed.

Details of recommendations for riprap and gabion revetments are outlined in the report and illustrated in details in the Appendix. Riprap and gabion revetments provide erosion protection but do not act as retaining structures, and therefore the slope angle is limited by the characteristics of the underlying soil types. For either riprap or gabion revetments, we recommend the slopes be cut to not steeper than 2H:1V. At some sites, particularly site 3A, extensive cut will be necessary to achieve the recommended maximum slope of 2H:1V, and land acquisition may be necessary. However, potentially technically feasible alternatives such as gabion breakwaters or gabion retaining walls would require launching gabions from a barge, and would likely be more costly, based on our discussions with Commonwealth Biomonitoring.

Report Prepared By:

Peter S. Lee, Ph.D., P.E.  
Senior Engineer

Report Reviewed By:

Elizabeth M. Dwyre, P.E.  
Geotechnical Services Manager

## 1. PROJECT DESCRIPTION

### 1.1 Introduction

ETS has performed a geotechnical evaluation for the shoreline protection against the wave energy at the selected sites along the shoreline of Lake Lemon. Lake Lemon is located about 10 miles northeast of Bloomington, in the rural area of Unionville, Indiana, as shown on Figure 1 in the Appendix, Site Vicinity Map. The following sections discuss the erosion site locations, project history, proposed construction, and ETS' scope of services.

### 1.2 Erosion Site Locations

A total of ten (10) most severely eroded sites along the shoreline were selected by Commonwealth Biomonitoring, Inc. in conjunction with the Lake Lemon Conservancy District and Indiana Department of Natural Resources (IDNR) for geotechnical evaluation. These ten (10) sites were generally divided in three groups, 1, 2 and 3. Sites 1A and 1B were located on the west side of Lake Lemon, and to the east of the existing dam, and site 1C was located on the northeast side of Cemetery Island in the middle of the lake. Sites 2A, 2B, and 2C were located on the south side of lake, to the east of Riddle Point Park. Sites 3A, 3B, and 3C were generally located on the north side of the Lake, and to the north and east of Riddle Point Park. The erosion site locations are shown on the Erosion Sites Location Plan, included on Figure 3 in the Appendix, which was reproduced from the Exhibit 1A site map provided by Commonwealth Biomonitoring, Inc.

### 1.3 Project History

Lake Lemon is a man made lake created by a dam on Beanblossom Creek. The dam was constructed in 1954. The lake is used primarily for recreational purposes but also serves as a secondary water supply reservoir for the City of Bloomington. Erosion has occurred along multiple locations around the lake, and has been mitigated at some locations by placement of riprap and

construction of timber retaining wall structures by private landowners. The Lake Lemon Conservancy District and IDNR plan to mitigate major erosion areas along the lakeshore to protect water quality.

#### **1.4 Design Wave Information**

Based on a site map prepared by Commonwealth Biomonitoring, Inc., the ten (10) severely eroded sites selected for evaluation were mapped as Category 1 Wave Energy Zone, sustained waves greater than 2 feet, with identified critical erosion. The maximum design wind generated wave height shown on the site map was 3.4 feet. The design boat generated wave height was 3 feet. Commonwealth Biomonitoring estimates a turbulence zone extending to about 2 feet below normal water level. Wave runup will be calculated by Commonwealth Biomonitoring based on topographic surveys of the sites under evaluation.

Normal water level is elevation 630, and we understand the lake level is relatively stable at that level due to the large ogee spillway. A 48 inch diameter pipe is formally designated as the primary spillway; the ogee spillway is the emergency spillway.

#### **1.5 Proposed Construction**

We understand Commonwealth Biomonitoring and the Lake Lemon Conservancy District have selected either riprap or gabion revetments, with planted trees and shrubs in the voids, as preferred alternatives for design. Gabion breakwaters were also under consideration but based on ETS' discussions with Commonwealth Biomonitoring, we understand breakwaters likely will not be selected for final design due to cost considerations.

We understand the water level during construction can be lowered 2 to 3 feet below the normal water elevation of 630, but due to the limited capacity of the discharge pipe, it may not be feasible to reliably maintain the lake at this level. We understand Commonwealth Biomonitoring is

pursuing further information regarding the period of time for which a specified construction water level can be maintained.

#### 1.6 Scope of Services

Our services for this project have been performed in general accordance with the terms of our proposal 97GO042, as authorized on April 17, 1997. The scope of our services for this project included:

- Visual reconnaissance of the lake and shorelines by an ETS geotechnical engineer, to observe the erosion features and observe surface evidence of slope movements, such as scarps, toe bulges, and leaning docks or trees.
- Dynamic Cone Penetration tests and hand augering performed by a geotechnical engineer during the site visit, at three to four of the identified erosion areas.
- Laboratory testing performed on samples recovered from the hand augering, including grain size distribution, natural moisture, and Atterberg Limit determination.
- For areas where erosion is currently limited to the shoreline, without associated movements of the upland bank, evaluation of the effectiveness of riprap and gabions.
- For areas where the upland banks show signs of active or past sloughing or sliding, development of a proposed program of subsurface exploration, laboratory testing, and evaluation, to be performed as a second phase of this evaluation, if authorized.
- Preparation of this report, presenting our site observations, results of field and laboratory testing, recommendations regarding erosion protection measures, and recommendations for additional exploration and evaluation in areas with active or past slope movements.

This phase of the project is limited to recommendations to protect the shoreline from further erosion by wave energy. Analysis of slope stability based on upland translational and rotational forces is outside our scope of services for this phase.

This report has been prepared under the direction of a Professional Engineer registered in the State of Indiana. Our services have been performed in accordance with generally accepted standards and procedures in the practice of geotechnical engineering. This report is prepared for ten (10) erosion sites based on the observed condition as of April 18, 1997. In the event of revisions or additions to the erosion sites, or construction of wave energy absorption systems or modifications to the slopes, other than those were recommended in this report, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed, and the conclusions and recommendations confirmed or modified in writing by ETS.

## 2. PROCEDURES

### 2.1 Site Visit

Ten (10) shoreline erosion sites were selected by Commonwealth Biomonitoring, Inc. for Phase I geotechnical investigation. A site visit was made by an ETS geotechnical engineer, Peter S. Lee, Ph.D., P.E., on April 18, 1997 for visual reconnaissance of the erosion sites at Lake Lemon, to observe the erosion of slopes, to observe surface evidence of slope movements, to perform the dynamic cone penetration (DCP) tests, and to collect soil samples for laboratory testing by using a hand auger. Field reconnaissance was performed from the water accompanied by Mr. Steve Chafin, in a boat provided by Commonwealth Biomonitoring. Field reconnaissance on land was also performed by the ETS engineer. These ten (10) sites are generally accessible by road with the exception of Site 1C where the only access is by boat. Photographs were also taken of the existing shoreline at the erosion sites during this visit and are included in the Appendix.

### 2.2 Subsurface Exploration

The soil exploration program of this phase was limited to sampling by using a hand operated auger and obtaining the blow counts by using a Dynamic Cone Penetrometer (DCP). Auger sampling was performed in 3 sites, 1B, 1C, and 2A. The general locations of the sites where hand auger sampling was performed are shown on a plan included as Figure 2, Erosion Sites Location Plan, in the Appendix of this report.

Sampling was performed using a hand-operated auger to depths of about 3 to 4 feet. Representative disturbed soil samples were generally obtained between about 1 to 3 feet below existing grade. The sampling procedure by hand-operated auger is in general conformance with ASTM Standard D 1452, Soil Investigation and Sampling by Auger Borings.

A DCP was used to evaluate the relative density of the primarily non-plastic soils. The number of blows required to drive the DCP 6 inches with a 10 pounds hammer, falling 2 feet, is recorded

as DCP blow counts. After DCP blow counts were obtained, these numbers were converted to approximate Standard Penetration Test (SPT) values (N-values). The SPT N-value is used in numerous geotechnical correlations, and is obtained from conventional soil borings. The SPT N-values is defined as the number of blows of a 140 pound hammer, falling 30 inches, required to advance a split spoon sampler 12 inches. The general relationship between DCP blow counts and N-values is about 2.5 to 3 DCP blow to 1 SPT blow. This correlation can vary with soil type and location of the groundwater table.

Unconfined compressive strength of soil samples were estimated in the field using a calibrated pocket penetrometer on cuttings from the hand auger. The estimated unconfined compressive strengths were estimated to the nearest  $\frac{1}{4}$  ton per square foot (tsf) by measuring the resistance of the soil samples to penetration by a small, calibrated, spring loaded cylinder. The maximum limit of the calibrated penetrometer is  $4\frac{1}{2}$  tsf; values above this are designated as  $4\frac{1}{2} +$  tsf.

Groundwater level observations were also made in the borehole during and upon completion of the hand-operated auger sampling.

The samples collected from the hand-operated auger sampling procedures were placed in glass jars. The soil and rock samples were transported to our laboratory for further testing and classification.

### **2.3      Laboratory Testing**

The laboratory testing program included visual engineering classification of the samples recovered and moisture content tests on cohesive soil samples. Atterberg Limit tests, sieve analyses, and hydrometer tests were performed on selected samples. The results of the laboratory tests are attached in the Appendix. Test methods are discussed below.

The soil samples were visually classified in the field by the geotechnical engineer, based upon texture and plasticity, in general conformance with the Unified Soil Classification System. Upon

the completion of laboratory testing, the visual classification was adjusted if necessary to conform to the obtained laboratory test results.

Moisture contents of soil samples were determined in general accordance with ASTM D 2216. The Atterberg limits and grain size distribution of the cohesive soils were obtained in general accordance with ASTM Standard D 4318 and D 422, respectively, as an aid in classification of cohesive soils.

The soil samples will be retained in our laboratory for 60 days, at which time we will dispose of them. If you wish to retain the samples, please notify us.

### 3. RESULTS

#### 3.1 Topography

The sites are located in an area of rolling hills with well-developed dendritic drainage. As shown on the USGS map included as Figure 2 in the Appendix, the lake is surrounded by scattered residential development, with portions of Morgan Monroe State Forest located to the north and south of private residential properties. Based on the site topographic plan prepared by the City of Bloomington GIS, the ground elevations in the upland ranged from 650 to 850 feet, and slopes as steep as 2H : 1V are common in the upland area of the lake. The USGS topographic map is reproduced in this report as Figure 2, USGS Site Plan. We understand the normal water elevation in the lake is about 630 feet and high-water elevation is about 632 feet after 24 hours of heavy rainfall.

#### 3.2 General Geology

Based on the Indiana Regional Geologic Map of Indiana, unconsolidated deposits along the shoreline consist of residual soils degraded from the bedrock, or lacustrine deposits consisting of loessial silty clay, silt, silty fine sand with clayey binder of former lake areas.

The residual soil at the project site is mapped by the Soil Conservation Service (SCS) as Pekin silt loam (PeB) and Elkinsville silt loam (EkF). Pekin silt loam (PeB) is generally located in the bottom land, about 2 to 6 percent slopes. This gently sloping, moderately well drained soil is moderately deep to a fragipan. It is on broad low terraces along drainageways. In a typical profile the surface layer is dark brown silty loam about 5 inches thick. The subsoil is about 49 inches thick. It is yellowish brown, friable silt loam in the upper part; is pale brown and yellowish brown, mottled, firm silty clay loam in the middle part; and has a fragipan of light yellowish brown and brownish yellow, mottled, very firm and brittle silt loam in the lower part. The substratum to a depth of 60 inches or more is light brown, pinkish gray, and reddish yellow stratified silt loam,

loam and sandy loam. In places the subsoil is less than 40 inches thick. Included with this soil in mapping are small areas of well drained Elkinsville soils.

According to the SCS description, Elkinsville silt loam (EkF) in the upland, about 20 to 40 percent slopes, is generally steep to very steep, deep well drained soil is on terraces which are in steep areas adjacent to bottom land. The available water capacity of this Elkinsville soil is very high, and permeability is moderate. Surface runoff is very rapid. The organic matter content of the surface layer is low.

According to the SCS report, many areas of this soil are in woodland. A few areas are used for grasses and legumes for hay or pasture. This soil is generally unsuited to cultivated crops because of the severe hazard of erosion and steepness of slope. Very rapid runoff, steepness of slope, and the hazard of erosion are the main concerns. A permanent cover of vegetation helps slow runoff and control erosion.

Based on Regional Geologic Map, the lakebed contained slabby limestone boulders and some limestone bedrock exposures. Based on published geologic sources, bedrock at the site is mapped as the lowermost part of Harrodsburg limestone, Borden Group, and Rockford limestone of Mississippi System, which consists primarily siltstone, shale, and fine-grained sandstone; thin limestone near top and at base. The maximum thickness of Borden Group and Rockford limestone is 800 feet where overlain by Salem limestone and major part of Harrodsburg limestone.

The site is located in Seismic Zone 1 as defined in the Unified Building Code, 1988 Edition.

### **3.3 Shoreline Erosion Observations**

The erosion sites generally consist of an immediately upland slope of about 4H to 2H : 1V and were well covered by vegetation. The shoreline erosion and very steep slopes were generally observed at the toe (refer to the photographs in the Appendix), and generally appeared to have been

triggered by wave energy erosion, with weathering by freezing and thawing contributing to the erodibility of the materials. The approximate upland and toe slopes, soil type, the approximate maximum height of the eroded slopes, are listed in Table 1.

Table 1, Site Reconnaissance

Site No.	Visually Estimated Eroded Slope	Visually Estimated Upland Slope	Approx. Max. Slope Height at the Toe ** (ft)	Visual of Exposed Soil Type	Indication of Upland Slope Movements*
1A (West)	about 1H : 1V to ½H : 1V	about 4 H : 1V	7	Silty Clay to Clayey Silt	Not Observed
1A (East)	about 1H : 1V	about 4 H : 1V	3	Silty Clay to Clayey Silt	Not Observed
1B	about ½H : 1V to Nearly Vertical	about Level to 2H : 1V	4	Silty Clay (1'-3') Clayey Sand & Gravel (at the toe)	Slough, about 60' x 60' Leaning Trees
1C	Nearly Vertical	about Level	4	Clayey Silt (1'-3') Silt (3'-4') Silt (at the toe)	Not Observed
2A	about ½V : 1V	about Level to 2H : 1V	6	Silt	Not Observed
2B	about ½H : 1V	about 2H : 1V	7	Clayey Silt	Not Observed
2C	about 1H : 1V	about 2H : 1V to 4H : 1V	4	Clayey Silt	Not Observed
3A	Nearly Vertical	about 2H : 1V	12	Clayey Silt to Silt	Not Observed
3B	about ½H : 1V to Vertical	about 4H : 1V	6	Silty Clay to Clayey Silt	Large Leaning Tree
3C	Nearly Vertical	about 4H : 1V	7	Clayey Silt to Silt	Not Observed

\*Note : "Not observed" indicates slope movements were not observed at more than about 5 feet inland. Local sloughs were observed within 3 to 5 feet from edge of bank at multiple locations.

\*\*Note: Height visually estimated above normal water level.

The erosion sites generally consist of silty clay to clayey silt soils on the immediately upland slope, and silt with some sand and gravel at the toe. Silty soils without protection are susceptible to the erosion and freezing and thawing effects. Riprap and concrete masonry were present at the toe of slope at Sites 1A, 2C and 3C. No seepage or wetland-type vegetation was observed near the toe of the slope at the ten subject erosion sites.

Slope movement extending more than about 5 feet from the edge of bank was observed at two of the ten areas, Site 1B and Site 3B. At the other eight sites, local sloughs were frequently observed within 3 to 5 feet of the edge of bank, but were not observed further upland. At one of these sites, Site 3A, the bluff created by erosion was about 12 feet above the water level at the time of our site visit. Sites 1B, 3B, and 3A are discussed below.

At Site 1B, a scarp about 6 inches high was observed bounding an area of about 60 feet by 60 feet, as shown in a site photo in the Appendix. The scarp appeared to be old and shallow, and was covered by grass. The area bounded by the scarp was hummocky, and small leaning trees were observed on the slope. However, a mature located near the toe of the slope was not leaning, which is suggestive of a possible relatively shallow translational slope failure, rather than a deep seated rotational failure. However, the depth of failure plane can not be determined visually. Slope failures often occur due to undercutting of the toe; however, within the area bounded by the scarp, the undercutting at the toe was only about 1 foot above the water level at the time of the site visit. We understand Commonwealth Biomonitoring has observed animal burrows in this area, which may have furthered erosion under the bank.

A large tree was observed leaning toward the lake at Site 3B (see site photo in the Appendix). Based on the information provided by Mr. Steve Chafin, this large tree is frequently used as perch by the resident and migratory bald eagles at Lake Lemon, and the tree should not be removed during slope protection activities.

At Site 3A, the toe of the slope and previously placed riprap were severely eroded, as shown in the site photo in the Appendix. Based conversations with Mr. Steve Chafin with Commonwealth

Biomonitoring, Inc., we understand the landowner previously placed a layer of at the toe of slope at Site 3A, but the riprap failed, possibly due to insufficient height or weight to resist the wave energy. Following the failure of riprap, the slope was undermined and collapsed. The slope is nearly vertical and was visually estimated to be as high as about 12 feet above normal water level. The vertical slope failure plane shows signs of continuous caving and erosion. Stabilization of this slope is necessary to prevent further sloughing.

Observed indications of upland slope failures at the ten subject sites are summarized in this section. It is possible, however, that surface indications of old landslides, scarps or cracks could have been hidden under the heavy vegetation at the time of the site visit. Also, marginally stable slopes may not exhibit signs of impending instability, and continued erosion may cause future failures. Therefore, we cannot be certain that upland slope stability concerns are limited to the areas discussed above.

### 3.4 Soil Conditions

The soil conditions encountered on the slope consisted of brown silty clay to clayey silt, and silt with some sand and gravel at the toe of the slope. Hand auger sampling was performed on the slope and at the toe at Sites 1B, 1C, and 2A. The site location were generally selected based on the site accessibility. The soil type, content of sand and gravel, silt, and clay, unconfined compressive strength based on the calibrated penetrometer ( $q_p$ ) on cutting samples, and DCP blows counts per six inches at the varied depths of each site are listed as follows:

The silty clay to clayey silt soils were generally stiff to very stiff, with unconfined compressive strengths based on the calibrated penetrometer test ranging from 1 to 2 tsf and moisture contents ranging from 18 to 25 percent. Liquid limits of the silty clay were about 39 and 50 percent, and plastic indexes were about 17 to 31 percent.

The clayey silt to silt soils were generally loose to dense, with DCP blow counts ranging from 13 to over 100 per foot, which are equivalent to Standard Penetration Tests (N-values) of 5 to 32 blows per foot (bpf).

Table 2, Soil Type and Descriptions

Site	Depth (ft)	Soil Type	Sand & Gravel (%)	Silt (%)	Clay (%)	q <sub>p</sub> (tsf)	DCP (Blows / 6 inches)	Equivalent SPT (Blows / 6 inches)
1B	1.5 - 3 (slope)	Silty Clay	8.9	30.6	60.5	1½	11-11-9	4-4-3
	3 - 4.5 (slope)	Silty Clay	---	---	---	---	8-7-8	3-2-3
	0.5 - 2 (toe)	Silty Clay	---	---	---	---	30-50-50	10-17-17
1C	1 - 2.5 (slope)	Silty Clay	3.7	62.4	33.9	1	6-7-18	2-2-6
	3 - 3.5 (slope)	Silt	---	---	---	---	---	---
	4.5 - 6 (toe)	Silt	---	---	---	---	30-37-45	10-12-15
2A	0.5 - 2 (slope)	Clayey Silt to Silt	22.4	54.8	22.8	---	4-5-8	1-2-3
	0.5 - 2 (toe)	Clayey Silt to Silt	---	---	---	---	60-50-54	20-16-18

The soil description herein is a generalized soil conditions at the boring locations. Actual subsurface conditions may vary from one area to another and from these conditions encountered at the soil boring locations.

#### 4. ANALYSES AND RECOMMENDATIONS

Based on the site visit observations, soil information obtained during hand auger sampling, laboratory test results, and our analyses, we present the following geotechnical conclusions and recommendations related to the existing shoreline erosion due to wave energy at these ten (10) sites. Our analyses have resulted in conclusions and recommendations which are discussed in the following sections.

##### 4.1 Erosion Evaluation

Based on the field observations, and the limited sampling and laboratory testing program, we conclude the severe loss of the soil slopes at the toes appears to generally be caused by wave energy erosion, with weathering by freezing and thawing contributing to the erodibility of the material.

The shoreline of Lake Lemon is exposed to wave energy created by the wind or boats. The shoreline erosion sites of interest are generally located in Category 1, which is defined as wave energy zone sustained waves higher than 2 feet with identified critical erosion. The maximum fetch distance and wave height were estimated by Commonwealth Biomonitoring to be about 13,100 feet and 3.4 feet, respectively. In general, the point of maximum curvature of a shoreline is particularly vulnerable to erosion. These ten (10) sites are generally located at or near the maximum curvature of the shoreline in that particular areas. The toes of these slopes are exposed to near-constant erosion by the wave energy, resulting in undermining of the toe and ensuing failure.

The other contributing factor of the shoreline erosion is weathering effects. Considering the nature of residual soils (mostly silty clay to clayey silt soils) which are highly susceptible to freezing and thawing, and have relatively poor drainage characteristics, weathering may occur at a rate rapid enough to be of concern. Weathering (primarily freezing and thawing) of soil destroys bonds and reduces shear strength. This occurs due to the destruction by weathering of diagenetic bonding in

these materials. Weathering may also be accelerated by slope disturbance and by exposure to atmospheric and other agencies such as wave action.

Landslides in soil slopes are often rotational or noncircular slumps, which can be visually identified from surface indications, such as the presence of scarps, leaning trees (tilted downhill near the head and uphill near the toe), bulges at the toe, cracks on the slope, or hummocky ground. At eight (8) of the ten (10) sites evaluated, such indications were not observed at the time of our site visit, other than local movements with 3 to 5 feet of the eroded shoreline. Slope movement observations are discussed in Section 3.3, Shoreline Erosion Observations.

#### **4.2      Erosion Control and Slope Stabilization**

Erosion at the toe of slopes by wave energy and weathering along the shoreline of Lake Lemon is common and can cause instability if slopes are left unprotected. We understand this phase of the project is limited to the protection of ten (10) of the most eroded sites from further damage by wave energy.

In general, for the ten subject sites, we anticipate adequate erosion protection for the design wave conditions can be achieved with riprap or gabion revetments, except at sites 1B and 3B. For site 1B, where there is evidence of upland sloughing, additional measures such as drainage may be necessary to reduce the risk of continued slope movement, as discussed in Section 4.3, Future Upland Slope Stabilization. For site 3B, protection of the area of the large leaning tree is not practical without placement of fill in the lake, which we understand is not feasible based on permitting considerations. Therefore, a “do nothing” alternative in the immediate area of the tree may be the most practical alternative. Over time, continued erosion is likely to cause the tree to fall, at which time the area may be graded and slope protection installed.

Riprap and gabion revetments provide erosion protection but do not act as retaining structures, and therefore the slope angle is limited by the characteristics of the underlying soil types. For either

riprap or gabion revetments, we recommend the slopes be cut to not steeper than 2H:1V. At some sites, particularly site 3A, extensive cut will be necessary to achieve the recommended maximum slope of 2H:1V, and land acquisition may be necessary. However, potentially technically feasible alternatives such as gabion breakwaters or gabion retaining walls would require launching gabions from a barge, and would likely be more costly, based on our discussions with Commonwealth Biomonitoring.

We understand Commonwealth Biomonitoring would prefer to install the slope protection system around existing standing trees and large fallen trees, to the greatest extent practical. Riprap provides greater flexibility in installation around obstructions than gabions. Gaps between the slope protection system and an obstruction could create local undermining, which could gradually expand to compromise the integrity of a large area of the slope protection system. While gabions may not be well suited to sites where obstructions must be accommodated, the smaller stone size required for fill in gabions will be easier to transport, particularly to the less accessible sites. Also, based on estimated unit costs of gabions and dumped riprap provided by Commonwealth, gabions may be less expensive. Furthermore, gabions are better suited to construction in the wet than riprap, which may be a consideration if the lake level cannot be reliably maintained at a suitable level during construction. Therefore, the optimal solution may vary from site to site.

Prior to the construction of riprap or gabion revetments, we recommend the slopes beneath the gabions be graded to be no steeper than 2H : 1V. Prior to the placement of riprap or gabions, the subgrade should be prepared by removing vegetation, organic topsoil, and soil which has sloughed or slumped. Sloughed or slumped soil will not provide an adequate base for the riprap due to the potential for resumption of slope movement along the past failure plane, particularly in response to changes in water levels. After the removal of the unsuitable materials, the site should be graded to the recommended maximum slope. If fill is required for grading, any areas to receive fill should be properly benched to incorporate the fill into the existing slope. Criteria for fill placement are provided in the following Section 4.2.4, Engineered Fill.

Details of recommendations for gabion revetments and riprap are outlined in the following subsections and illustrated in details in the Appendix.

#### 4.2.1 Gabion Revetments

Gabions are compartmented rectangular containers made of galvanized steel hexagonal wire mesh and filled with stone. The steel wire hexagonal mesh provides the strength and flexibility to withstand wave forces. The permeability and rough surface of a gabion revetment make it effective in dissipating and absorbing wave energy and lessening the extent of wave runup and overtopping.

Gabions can also be used to construct gravity retaining structures, resisting earth pressure. However, the application recommended in this report is a revetment and is designed to provide erosion protection, but not to retain earth pressures.

Prior to the construction of gabion revetments, we recommend the slopes beneath the gabions be graded to be no steeper than 2H : 1V. Subgrade preparation is discussed in Section 4.2 above. A permeable geotextile filter fabric should be placed on the graded bank, prior to placement of the gabions, to inhibit loss of soil into the gabions.

A schematic detail of the recommended gabion revetment is included as Figure 4 in the Appendix. The recommended gabion revetment design includes a flexible gabion apron intended to settle without fracturing and adhere to the ground as toe scour occurs. Little or no excavation is required for constructing gabion apron. The bed should be roughly leveled and the gabion apron be placed directly on the ground. If the depth of water at the time of construction is considerable, the lake bed may be built up by dumping granular material until it reaches a level where the gabion apron can be placed conveniently.

To avoid lifting and overturning of a gabion apron, we recommend a minimum gabion thickness of 12 inches in the apron portion. To provide effective protection, the gabion apron must be of sufficient length to reach the outer limit of the potential scour hole. Typically, the projection of the

apron beyond the toe of the gabion revetment is about  $1\frac{1}{2}$  to 2 times the estimated depth of scour at the toe, as shown in Figure 4. Commonwealth Biomonitoring estimated the toe scour elevations ranging about 627.6 to 627.8, about 2 feet below existing lake bed elevation at the toe of slopes. Therefore, we recommend gabion apron projected at least 4 feet beyond the toe of the gabions.

Above the gabion apron, the gabion revetment may be constructed to a minimum elevation equal to the design wave runoff elevation. We recommend a minimum gabion thickness of 12 inches for banks having slopes no steeper than 2H : 1V.

The geotextile placed on the graded slope should meet Indiana Department of Transportation (INDOT) 1995 Standard Specifications Section 913.18, Geotextile for Use Under Riprap. Gabion baskets should be as manufactured by Maccaferri, or an equivalent approved by Commonwealth Biomonitoring. The gabion baskets should be placed on the geotextile and filled with stone meeting INDOT Standard Specification Section 616.02, with particle size between 4 to 10 inches. Following placement and filling of the gabions, the void between the back of gabions and the slope should be properly filled with engineered fill. Engineered fill criteria are provided in Section 4.2.4 of this report.

#### 4.2.2 Riprap

As an alternative to the gabion revetment, we recommend layers of riprap be placed at the toe of the slopes and extended to the mean high pool elevation plus maximum wave height and wave runoff. Prior to the construction of gabion revetments, we recommend the slopes beneath the gabions be graded to be no steeper than 2H : 1V. Subgrade preparation is discussed in Section 4.2 above. A permeable geotextile filter fabric should be placed on the graded bank, prior to placement of the riprap, to inhibit loss of soil into the riprap.

A minimum 2 feet wide key with 1V: 1H side slopes should be provided at the toe of riprap revetments and encased with an acceptable geotextile filter fabric. The key should be extended to a minimum depth of 3 feet below the toe of the slope. We recommend the excavation for

the keys and placement of riprap should take place in a timely fashion to prevent excessive trench wall cave-in. Alternately, a dumped riprap toe berm may be used if the lake level cannot be adequately controlled to permit construction of the key trench in the dry.

Figure 5 shows the geotextile fabric liner coming up from the bottom of the key, covering the slopes, and then running over the top a short distance. The liners are terminated vertically in an anchor trench with a minimum depth of 3 feet, and minimum width of 2 feet. This anchor trench can be dug with a small backhoe or trenching machine, the liner draped over the edge of the trench, and the trench backfilled with the engineered fill as recommended in Section 4.2.4.

Riprap can be dumped or hand-placed. We understand only dumped riprap is under consideration for this project. Dumped riprap consists of large-sized rock placed on a geotextile filter fabric. A geotextile filter fabric must be provided and enough openings should be left in the riprap facing to permit easy flow of water into or out of the riprap. The geotextile filter fabric should meet the requirements of INDOT 1995 Standard Specifications Section 913.18, Geotextile for Use Under Riprap.

The surface to receive the geotextile should be prepared to a relatively smooth conditions free of obstruction, depressions and debris. The geotextile should be placed in such a manner that placement of the overlying materials will not excessively stretch or tear the geotextile and will not pull the required overlap or seam apart. Geotextile used for 2H : 1V slope or less should be placed with the machine direction of the geotextile parallel to the shoreline. Successive geotextile sheets should be overlapped in such a manner that the upslope sheet over downslope sheet. The installation of the geotextile should meet the requirements of INDOT 1995 Standard Specifications, Section 616.10, Installation of Geotextile Under Riprap.

Riprap should be hard and durable against weathering and heavy enough to resist displacement by wave action. We recommend the dumped riprap should have a minimum nominal thickness of 24 inches. The riprap material should conform to INDOT 1995 Standard Specification, Section

616.02(a), Dumped Riprap. In addition to the INDOT Specification requirements, riprap should meet the following gradation criteria:

1. No individual piece weighs more than 600 pounds or less than 20 pounds.
2. 20 to 60 percent of the material has a maximum particle size of 12 inches.

The riprap should be placed in accordance with INDOT 1995 Standard Specification, Section 616.03, Placing Dumped Riprap.

#### **4.2.3 Gabion Breakwaters**

Due to the privately owned property at Site 3A, we understand gabions as a shore-connected breakwater without was also considered by Commonwealth Biomonitoring for wave energy absorption at this site. However, this would require launching gabions from a barge, and mobilizing barge-mounted equipment to the site would be costly. Also, a shore-connected gabion breakwater would reduce the risk of additional undermining by continued erosion, and would therefore reduce siltation, but would not stop the currently oversteepened slope from sloughing back to its natural angle of repose.

#### **4.2.4 Engineered Fill**

Engineered fill placed for site grading or as backfill against the back face of the gabion revetment should be inorganic, environmentally clean, and free of lumps or frozen soils or other deleterious materials. We anticipate on-site materials such as silty clay may be re-used for engineered fill. Moisture contents of these soils may be difficult to control during periods of wet and cool weather.

Engineered fill should be placed in lifts not exceeding 9 inches in loose thickness and be compacted to a minimum of 95 percent maximum dry density as determined in accordance with ASTM Standard D 698 (Standard Proctor).

#### **4.3 Future Upland Slope Stabilization**

At Site 1B, there is a risk that slope movement in upland slough area could resume, particularly in response to seasonal changes in rainfall and groundwater conditions. To provide detailed recommendations regarding mitigation of potential movement in this area, ETS would need to perform soil borings to identify the depth of the failure plane and obtain information regarding soil properties. We would then perform slope stability analyses, modeling existing and proposed slope conditions with a range of anticipated water conditions. Although we cannot make a determination regarding appropriate mitigation measures without further study, it is likely that a perimeter drainage trench ("french drain") along the scarp, discharging to the lake, could be effective.

#### **4.4 Excavation**

Below grade excavations into natural soils are anticipated on this project. The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides and bottom. All excavations should comply with applicable local, state and federal regulations including the current OSHA Excavation and Trench Safety Standards. Construction site safety generally is the sole responsibility of the Contractor, who shall also be responsible for the means, methods and sequencing of construction operations.

In no case should slope height, slope inclination or excavation depth, including utility trench excavation depth exceed those specified in local, state and federal safety regulations. Specifically, the current OSHA Health and Safety Standards for Excavations, 29 CFR 1926 should be followed. We understand these regulations are being strictly enforced and if they are not closely followed, the Owner and Contractor could be liable for substantial penalties.

The contractor's "responsible person", as defined in 29 CFR 1926 should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. If an excavation, including a trench

is extended to a depth of more than twenty feet, it will be necessary to have the side slopes designed by a professional engineer registered in the state where the construction is occurring. The Contractor's "responsible person" should also establish a minimum lateral distance from the crest of the slope or excavation for all spoil piles and vehicles. Likewise, the contractor's "responsible person" should establish protective measures for exposed slope faces.

All excavations should be safely sheeted, shored or braced in accordance with OSHA requirements. If material is stored or equipment is operated near an excavation, stronger shoring must be used to resist the extra pressure due to the superimposed loads. Care should always be exercised when excavating near existing roadways, or utilities, to avoid undermining.

#### **4.5      Plan and Specification Review and Quality Control**

When modifications are designed, we recommend ETS be provided the opportunity to review the project plans and specifications pertaining to the geotechnical aspects of the gabions or riprap, prior to contracting for construction in order to ascertain that the design is as anticipated when the design recommendations were provided. All soils related activities, including excavation, gabions construction, and granular fill placement should be observed by the project geotechnical consultant to verify the work is being performed as specified in the project documents.

## 5. GENERAL COMMENTS

This report has been prepared under the direction of a registered Professional Engineer licensed in the State of Indiana. Our services have been provided in accordance with generally accepted geotechnical engineering practices, and are intended to aid in the evaluation of this site and to assist the engineer in the design of this project. In the event of changes in the design criteria or location of the sites to be stabilized, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed, and the conclusions of this report are confirmed or modified in writing by ETS.

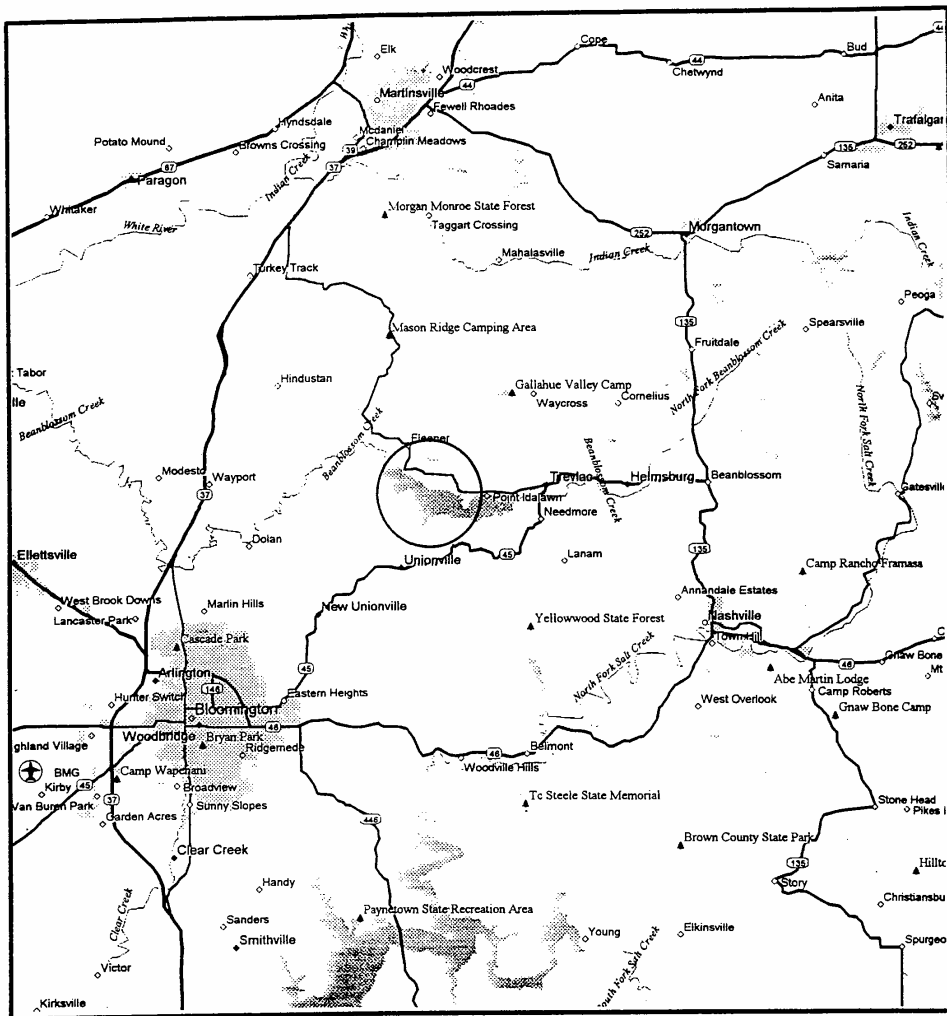
The analysis and recommendations submitted in this report are based upon the field observations, and data obtained from the three (3) hand auger sampling location performed at Sites 1B, 1C, and 2A. This report does not reflect variations in soil conditions which may not have been evident from the site observations and hand auger sampling. The nature and extent of variations may not become evident until the time of construction of remedial measures. If significant variations then become evident, it may be necessary to reevaluate the recommendations contained in this report. We recommend that the contract specifications include the following phrase:

"The contractor will, upon becoming aware of subsurface or latent physical conditions differing from those disclosed by the original soil exploration work, promptly notify the owner verbally to permit verification of the conditions, and in writing, as to the nature of the differing conditions. No claim by the contractor for any conditions differing from those anticipated in the plans and specifications and disclosed by the soil studies will be allowed unless the contractor has so notified the owner, verbally and in writing, as required above, of such differing conditions."

Our scope of services for this project consisted solely of a geotechnical evaluation. This report does not address any environmental or permitting considerations.

## **APPENDIX**

1. Figure 1, Lake Lemon Vicinity Plan
2. Figure 2, USGS Site Plan
3. Figure 3, Erosion Sites Plan
4. Figure 4, Gabion Revetment Design Illustration
5. Figure 5, Riprap Design Illustration
6. Figure 6, Riprap with Berm Design Illustration
7. Site Photographs
8. General Notes
9. Grain Size Test Reports (3)



○ Site Location

**ETS**  
Engineering & Testing  
Services, Inc.

**Project:** Lake Lemon  
**Client:** Commonwealth Biomonitoring, Inc.  
**Location:** Unionville, Indiana  
**ETS Job No.:** I6651  
**Date:** 4/97  
**Scale:** Not To Scale

**Figure 1**

site  
vicinity map

7225 Georgetown Road, Indianapolis, Indiana 46268-4126



Source: U.S.G.S. Hindustan, Indiana 7 1/2 Minute Topographic Quadrangle, Photorevised 1980

**ETS**  
Engineering & Testing  
Services, Inc.

**Project:** Lake Lemon  
**Client:** Commonwealth Biomonitoring, Inc.  
**Location:** Unionville, Indiana  
**ETS Job No.:** 16651  
**Date:** 4/97  
**Scale:** 1"=2000'+/-

**Figure 2**

**U.S.G.S.  
site plan**



Gabion  
revetment design  
illustration

Figure 4

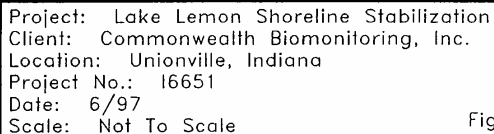
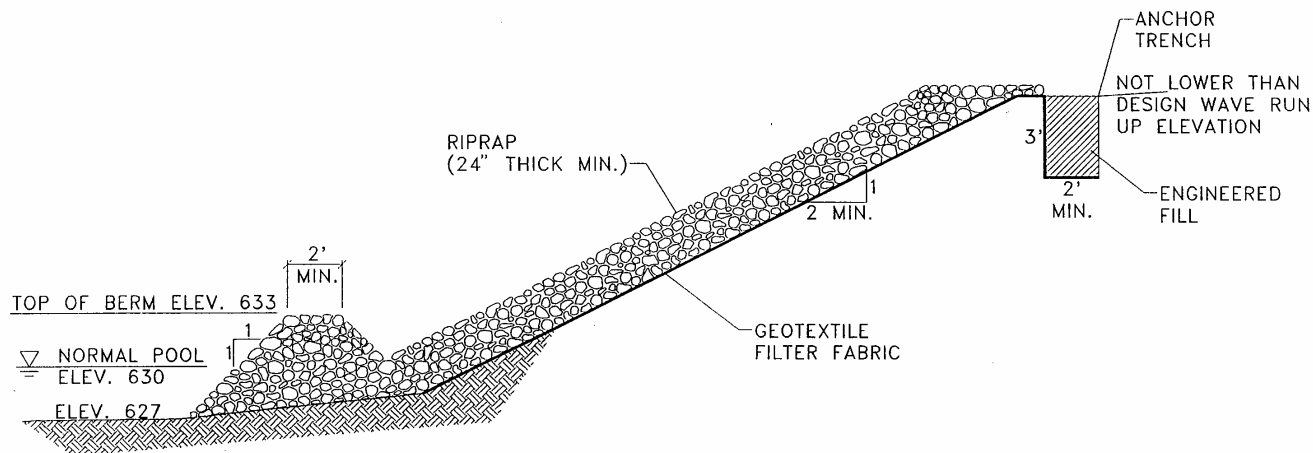


Figure 5



NOTE:  
ELEVATION OF TOP OF RIPRAP KEY MUST BE NO  
HIGHER THAN BOTTOM OF DESIGN TURBULENCE ZONE.



Project: Lake Lemon Shoreline Stabilization  
Client: Commonwealth Biomonitoring, Inc.  
Location: Unionville, Indiana  
Project No.: 16651  
Date: 6/97  
Scale: Not To Scale

Figure 6

riprap with  
berm design  
illustration



Site 1A (East), Photographed 4/18/97

.....



Site 1A (East), Photographed 4/18/97

.....



Site 1A (West), Photographed 4/18/97

---



Site 1A (West), Photographed 4/18/97

---



Site 1B, Photographed 4/18/97

.....



Site 1B, Photographed 4/18/97

.....



Site 1C, Photographed 4/18/97

.....



Site 1C, Photographed 4/18/97

.....



Site 2A, Photographed 4/18/97



Site 2A, Photographed 4/18/97



Site 2B, Photographed 4/18/97

---



Site 2B, Photographed 4/18/97

---



Site 2B, Photographed 4/18/97

.....



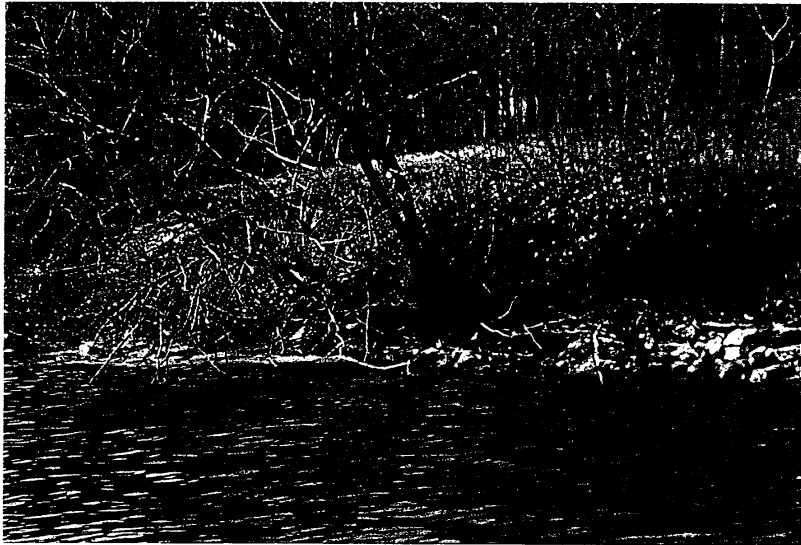
Site 2B, Photographed 4/18/97

.....



Site 2C, Photographed 4/18/97

.....



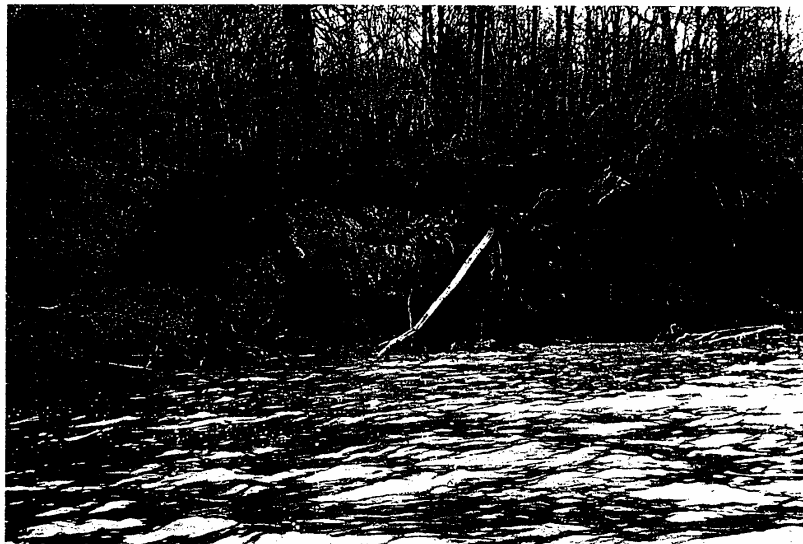
Site 2C, Photographed 4/18/97

.....



Site 3A, Photographed 4/18/97

.....



Site 3A, Photographed 4/18/97

.....



Site 3B, Photographed 4/18/97

.....



Site 3B, Photographed 4/18/97

.....



Site 3C, Photographed 4/18/97

---



Site 3C, Photographed 4/18/97

---



## GENERAL NOTES

### Drilling & Sampling Symbols

SS — Split Spoon — 1 3/8" I.D., 2" O.D., except where noted	HA — Hand Auger Boring
ST — Shelby Tube — 3" O.D., except where noted	BS — Bag Sample
PA — Power Auger	RC — Rock Core with diamond bit, NX size, except where noted
PS — Piston Sample — 3" diameter	RB — Roller Bit
WB — Wash Boring	N/A — Not applicable or available
WS — Wash Sample	

Standard Penetration Test "N" Value — Blows per foot after an initial 6 inch seating of a 140 pound hammer falling 30 inches on a 2 inch O.D. split spoon, except where noted.

### Water Level Measurement Notation & Symbols

First	— When noted during drilling or sampling process
Completion	— After all drilling tools are removed from borehole
HR	— Number of hours after completion
N/R	— Not recorded
Dry	— No measurable water level found in borehole

### Particle Sizes

Boulders	— Greater than 6" (152.4 mm)
Cobbles	— 3" to 6" (76.2 mm to 152.4 mm)
Gravel	— Coarse — 1/4" to 3" (19.05 mm to 76.2 mm)
Gravel	— Fine — (No. 4) 3/16" to 3/4" (4.75 mm to 19.05 mm)
Sand	— Coarse — No. 10 to No. 4 (2.00 mm to 4.75 mm)
Sand	— Medium — No. 40 to No. 10 (0.425 mm to 2.00 mm)
Sand	— Fine — No. 200 to No. 40 (0.074 mm to 0.425 mm)
Silt	— Minus No. 200 (0.005 mm to 0.074 mm)
Clay	— Less than 0.005 mm

Water levels indicated on the boring logs are the levels measured in the boring at the time indicated. The accurate determination of groundwater levels may not be possible with short term observations, especially in impervious soils. The level shown may fluctuate throughout the year with variations in precipitation, evaporation, runoff, and other hydrogeologic factors.

## CLASSIFICATION

### Cohesionless Soil

Relative Density	"N" Value (Blows/ft)
Very Loose	0 to 4
Loose	5 to 9
Medium Dense	10 to 29
Dense	30 to 49
Very Dense	50 to 79
Extremely Dense	Over 80

### Soil Constituents

"Trace"	Less than 10%
"Trace to Some"	10% to 19%
"Some"	20% to 34%
"And"	35% to 50%

### Cohesive Soil

Consistency	Unconfined Compressive Strength (tons/sq. ft.)
Very Soft	Less than 0.25
Soft	0.25 to 0.49
Medium	0.50 to 0.99
Stiff	1.00 to 1.99
Very Stiff	2.00 to 3.99
Hard	Greater than 4.00

### Soil Description Terminology

If clay content is sufficient so that clay dominates soil properties then clay becomes the primary noun with other major soil constituent as modifier, i.e. silty clay. Other minor soil constituents may be added according to estimates of soil constituents present, i.e. silty clay, trace to some sand, trace gravel.

PERCENT FINER

GRAIN SIZE - mm

Grain Size (mm)	Percent Finer (%)
200	100
100	100
60	100
40	100
20	98
10	98
7.5	97
5	96
3	94
2	92
1.5	90
1.0	88
0.75	82
0.6	78
0.425	74
0.3	68
0.25	65
0.2	62
0.15	58
0.125	52
0.1	48
0.075	42

	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.2	8.7	30.6	60.5

[illegible]

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty Clay, trace sand, trace gravel	CH	A-7-5(21)

Date: 5/1/1997

ENGINEERING & TESTING SERVICES, INC.


Material Source: Sample  
1B,S-2, 2.5-3.0'

Figure No. 1

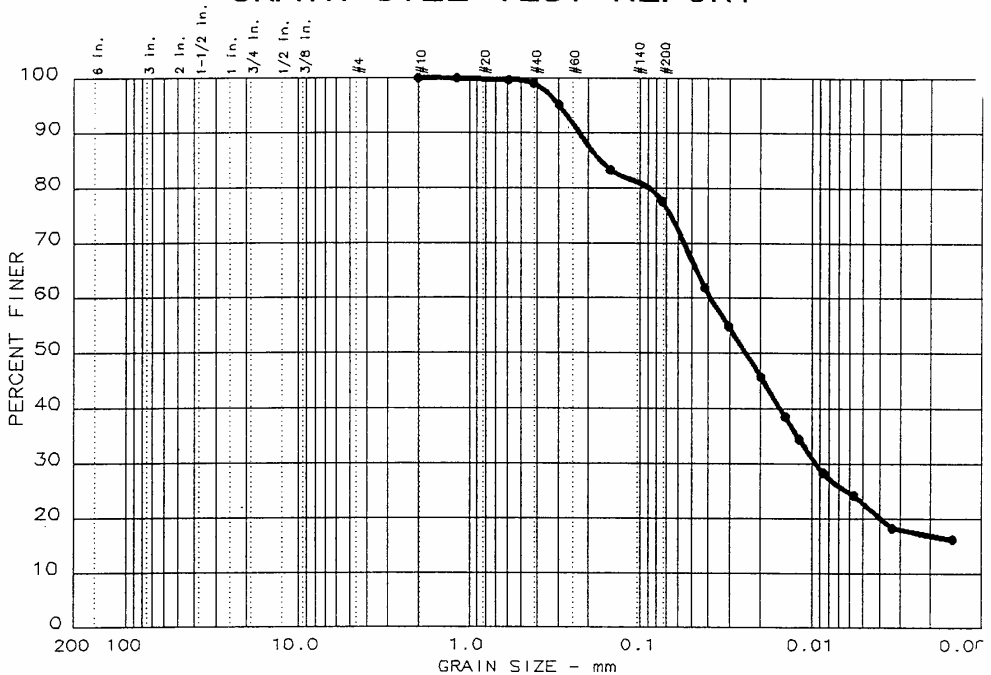
Grain size distribution curve showing Percent Finer versus Grain Size (mm). The curve indicates a sharp drop in percent finer between 0.075 mm and 0.0075 mm, suggesting a well-graded material with a narrow range of particle sizes.

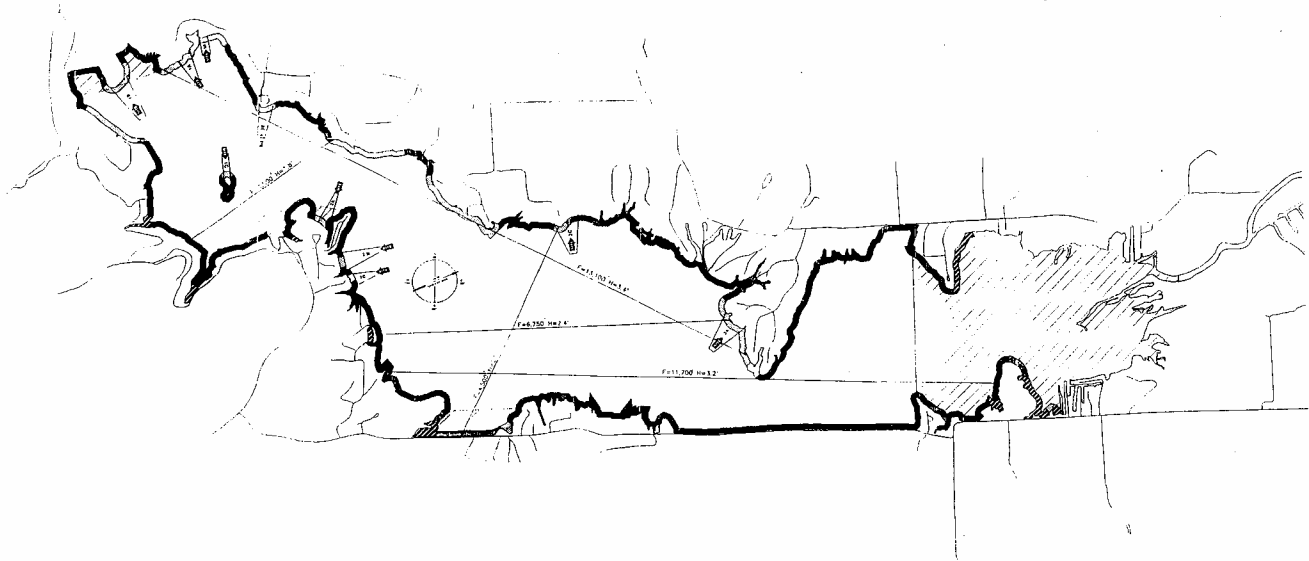
Grain Size (mm)	Percent Finer (%)
6 in.	100
3 in.	100
2 in.	100
1-1/2 in.	100
1 in.	100
3/4 in.	100
1/2 in.	100
3/8 in.	100
#4	100
#10	100
#20	100
#40	100
#60	100
#140	98
#200	95
0.075	85
0.06	78
0.0425	68
0.03	58
0.025	52
0.02	42
0.015	35
0.01	28
0.0075	25

[illegible]

Project No.: 16651 Project: Lake Lemmon Shoreline Erosion Protection • Location: Sample 1C, S-1, 1.0-1.5'  Date: 5/1/1997	Remarks: Date Sampled: 4/97 Material Source: Sample 1C, S-1, 1.0-1.5'
 GRAIN SIZE TEST REPORT ENGINEERING & TESTING SERVICES, INC.	Figure No. 2

# GRAIN SIZE TEST REPORT





**ETS**  
Engineering & Testing  
Services, Inc.

Project: Lake Lemon  
Client: Commonwealth Biomonitoring, Inc.  
Location: Unionville, Indiana  
ETS Job No.: 16651  
Date: 4/97  
Scale: 1"=2000'+/-

Figure 3

erosion sites  
location plan

## **Section 6**

### **Structures.**

- a. Assumptions.**
- b. Criteria.**
- c. Brief narrative description of resulting design**

## **Section 6. Structures**

The only structural considerations necessary for lake Lemon Shoreline Stabilization Project are the integrity of the proposed banks and the footing of the flexible revetement used on the slopes.

Each of these aspects are covered by the ETS report presented in Section 5.

## **Section 7**

**Environmental concerns (mitigation where applicable)**

## **Section 7. Environmental Concerns**

Due to the nature of the project, the actual environmental concerns are minimal. Damage to existing trees and construction activity sedimentation are the two primary environmental concerns of this project.

### **Tree Preservation**

The primary environmental concern of the project is the minimization of damage to existing shoreline trees. A negative aspect of excavation work is the removal of trees on the forested portions of the lake shore to gain access for slope dressing. The plans expressly instruct the contractor to prevent damage to all trees with a diameter breast high (DBH) of greater than 6 inches.

In addition, in an effort to reduce the amount of excavation performed at the sites, the toe of the rip rap flexible revetment is specified to be bermed rather than keyed into a trench for structural stability of the rip rap revetment. Therefore the extent of excavation activity has been minimized.

Generally, trees and their root matrix add stability to the banks. Although there are several trees on the Lake Lemon shoreline that present a wind throw hazard at the subject sites. Only trees that are presently leaning creating a short term risk of falling should be removed, and only under the approval of the on site inspector after consultation with the designer Commonwealth Biomonitoring, Inc.

Any trees that must be removed for shoreline reshaping should be placed along the shoreline, lakeward of the project so as not to interfere with work progress, for fish habitat and additional wave energy reduction.

In most cases, trees that present a wind throw hazard are removed in the course of construction. There is an economy of scale to address potential wind throws during the construction process rather than as a maintenance measure in the future. However, some of the specific trees on the Lake Lemon shoreline that presently present a wind throw hazard are also used frequently as perching sites for a variety of birds at Lake Lemon. Thus, it was deemed prudent to require only the minimum amount of tree removal and damage in the field for the project.

The types of hard and soft flexible revetment specified for this project were specified so that the measures could be placed around existing shoreline trees with minimal site prep necessary prior to placing the stone. The stone and geofabric can be placed around existing obstructions such as driftwood; wind throws; and existing, old failed shoreline revetment.

### **Planting of Trees**

Several species of native trees are specified to be planted in the project at each of the shorelines to be treated. The project will add substantial forested area to the shoreline.

## **Lakeshore Wetlands Considerations**

The loss of lakeshore wetland area calculated to be .0052 acres. With the lake margin wetlands being stabilized with either rip rap or bioengineered revetment, the littoral zone is expected to be less turbid, and provide increased habitat niches for utilization by the aquatic community. Where practical, to minimize costs, locally available materials will be specified where possible. Oolitic crushed limestone from southern Indiana quarries, trees removed for slope regrading or drift removed from the shore will be reused on site for a wave break and for fish habitat enhancement. Specified native vegetation will be from locally available sources where possible.

## **Construction Activity Sedimentation Control**

Because the lake level is anticipated to be up to normal pool during construction, there is no excavation cut planned for below the water surface. Some fill is required to push the toe of the slope lakeward in isolated areas. The contractor will be required to cover any and all exposed earth with geofabric and rip rap (below water line) prior to ceasing work at the end of each day. For exposed earth above the wave energy zone of 634.5' the contractor is required to cover this area with an straw erosion control blanket at the end of the day's work.

At no time shall the excavation proceed faster or expose more earth than what can be recovered and stabilized by the end of the work day.

## **Recommended In-Lake Shoreline Management Techniques**

The impacts of heavy boating use are a concern all across Indiana. Bigger, heavier, and more powerful boats are more popular than ever before. Their effects are beginning to show up more frequently in a variety of ways. Many reservoirs in Indiana have as much as 2/3 of their surface areas in idle zones or no wake zones. This is for the protection of shorelines and fish habitat and for boating safety in shallow water. Following are some in-lake management suggestions for shoreline protection that the LLCD may want to consider.

### **A. Motorboat Speed Limit Zones**

According to Indiana state boating laws there is a 10 MPH speed limit on boat operation within 200 feet of a lake shoreline. The LLCD may want to consider this a no wake zone rather than 10 MPH speed limit zone. At 10 MPH boats can still generate an erosive wake. Since there are few 200 foot marker buoys, in place aquatic vegetation could be used as a boat traffic management strategy.

### **B. Aquatic Macrophyte Management**

There possible aquatic vegetation could be left intact within 200 feet of the shoreline to discourage boat operation within 200 feet of the shoreline and to serve as a baffle to absorb some wave energy prior to the wave reaching the shoreline. A 200 foot buffer of vegetation would provide:

- Game fish, and prey fish habitat for a balanced aquatic ecosystem;
- tie up nutrients in macrophytes rather than algae, improving water clarity;
- buffer wave energy impacting the shoreline;
- filter the water column of suspended particles, improving water clarity;
- reduce herbicide treatment costs.

Lanes could be maintained through the vegetation to facilitate boat traffic to and from private docks.

## **Section 8**

**Land rights needed, including permanent  
and/or temporary flood easements**

## **Section 8. Land Rights Needed Easements**

For a map of site locations refer to Sheet 2 of the plan set.

Site 1A-1 is owned by the City of Bloomington Utilities located in the northwest corner of Lake Lemon.

Site 1C is the north side of north Cemetery Island and is owned by the City of Bloomington Utilities.

Site 3B is owned by the Lake Lemon conservancy District.

Due to the fact that the sites are all located wholly on property owned by the sponsoring entities Lake Lemon Conservancy District and the City of Bloomington utilities, it is deemed unnecessary to obtain legal easements for ingress/egress purposes.

Ingress/egress access to each of the sites is on land owned by the sponsoring entities.

All construction activity is to take place on City of Bloomington Utilities and Lake Lemon Conservancy District property.

## **Section 9**

**Special items, or materials required including  
plant lists and planting guides where  
applicable**

## **Section 9. Special Materials, Items, and Plant Materials Needed**

### **Special Materials For Areas Treated With Rip Rap Flexible Revetment**

#### **Geosynthetic Fabric**

The geosynthetic used beneath the rip rap shall meet the minimum performance standards of the INDOT geosynthetic for use beneath rip rap specification 913.16.

The Carthage Mills 8% woven monofilament meets this minimum standard specification. An approved equal may also be used.

#### **Rip Rap Stone**

The minimum rip rap size for use on this project is 8 inch diameter. To ensure that finer material which could be displaced is not included in rip rap, it is recommended that the minimum  $D_{50}$  (mean diameter) be 12 inch.

#### **Straw Erosion Control Blanket**

Disturbed areas above the zone of rip rap placement (above 634.5') shall be covered with a 100% straw erosion control blanket with minimum weight of 0.7lb/S.Y. The blanket shall have netting on two sides. The blanket shall be stapled with 6 inch sod staples utilizing the pattern specified on the plans.

#### **Seed Species**

All areas to be seeded shall be seeded with an endophyte free variety of tall fescue mixed with annual rye and perennial rye as indicated in the specifications. If the seeding is done in the winter or dormant period a nurse crop shall also be used of 56 pounds per acre of winter rye.

#### **Tree Saplings**

In the area above the rip rap pin oak and sycamore tree seedlings shall be planted to reforest the shoreline.

#### **Live Stakes**

In the rip rapped zone, live stakes of button bush and sandbar willow shall be inserted prior to placement of rip rap. The minimum diameter of the live stakes to be placed within the rip rap zone shall be 1 inch. The stakes shall be pushed into a pilot hole pushed into the soil and through the geosynthetic prior to rip rap placement. The stakes shall extend at least 18" into the bank below the ground surface, and extend at least 32" above the ground surface or 6" above the top of the rip rap whichever is greater.

## **Special Materials For Areas Treated With Coir Bioengineering Revetment**

### **Coir Rolls**

There are two sizes of coir rolls specified for use in this project. They are 20 inch diameter and 16 inch diameter. The coir rolls shall be enclosed in a 2"x2" synthetic twine mesh (with minimum test of 200 pounds), and shall have a minimum density of 9 lbs per cubic foot. The lengths shall be 10 feet.

### **Hardwood Stakes**

The hardwood stakes used shall be at least 2"x2" nominal thickness and shall be at least 36" long for staking 16" coir rolls and shall be at least 48" long for staking 20" coir rolls. Any broken or split stakes shall be replaced with an undamaged stake. Damage to the top of the stake from driving is acceptable, as long as the damage does not produce a split in the stake longer than 6 inches.

### **Gabion Wire**

The wire used to tie down coir bio rolls to the hardwood stakes shall be of the same grade used for lacing gabion baskets, and treated to resist corrosion by hot dipped or cold galvanizing. PVC coated wire is also an acceptable material. The wire must have a tensile test strength of at least 500 pounds.

### **Coir Blankets**

The coir erosion control blanket shall have a minimum blanket weight of 0.7 lbs per S.Y. and shall have a minimum material width of 8 feet. The blanket shall be stapled to the shoreline with at least 6 inch length sod staples utilizing the Staple Pattern E as specified in the plans.

### **Live Stakes and Seedlings**

Live stakes of sandbar willow and buttonbush shall be intermixed with seedlings of bald cypress in the zone between the wave break coir roll and the embankment toe protection coir roll. From the embankment coir roll up to the top of the treatment zone silver maple and sycamore seedlings shall be inserted in the bank.

# **Section 10**

**O&M considerations that have affected design**

## **10. OPERATIONS AND MAINTENANCE PLAN AND POST CONSTRUCTION MONITORING PLAN**

There are no continuous operations to perform, therefore, this report section will focus on maintenance activities.

### **10a. Description of Maintenance Work to be Performed**

The following report comprises the Engineer's suggested methods, strategies, and timing of maintaining the biotechnical shoreline stabilization treatments. The shoreline stabilization treatments have been designed to require a minimum of operator attention and minimize long term maintenance attention.

The maintenance to be performed will primarily consist of periodic inspection of shoreline areas for indications of vandalism (moving or tossing rip rap from shoreline areas) and damage to planted trees and shrubs from animals, vandals, or environmental extremes. If the LLC, as Owner, decides to inspect the revetment foundation for toe scour then the lake will have to be lowered to expose the revetment toe. In areas constructed with gabion mattresses this is not necessary, as mattresses simply hinge downward if scour occurs at their toe.

Following is a description of the tasks anticipated to properly maintain the biotechnical shoreline treatments so they provide long-term protection for the Lake Lemon shoreline.

- ☐ Inspection/repair of rip-rap and erosion control measures on treatment areas.
- ☐ Placement of rip rap flexible revetment over any exposed earth from future windthrows.
- ☐ Inspection of plantings of treatment areas for signs of vandalism, animal damage, or drought condition.

### **Inspection/Maintenance of Biotechnical Shoreline Treatments**

Site conditions may change from either natural or manmade causes which may cause the need for maintenance or repair of the flexible revetment. While damage to rip rap is unlikely, flood events beyond the design high water elevations coupled with high winds and vandalism are the most likely source of damage to rip rap structures. Therefore, inspections need only be performed after significant storm events and after lake level lowering when structures are visible.

### **10b. Projected Maintenance**

The shoreline stabilization measures should be inspected annually for any substantial movement of stone, and for any new wind throws. The plantings should be inspected for indications of animal or vandalism damage, and stress from poor soils or drought conditions. It is recommended that the operator be equipped with:

- ☐ boat, camera, notepad

### **Inspection of Rip-rap and Erosion Control Measures**

All exposed rip-rap should be inspected for stability on an annual basis. Any rip-rap that is misplaced or that has been moved should be replaced. The LLCDD presently has a policy to conduct an annual drawdown of the lake level for winter control of Eurasian milfoil. While the lake is lowered the shoreline inspection and any maintenance should be performed.

Any time the lake is temporarily dewatered, all rip-rap erosion control measures should be inspected and where stones have been moved by natural forces they should be replaced with heavier stones.

### **Inspection of Plantings**

Plantings should be inspected to ensure they are developing satisfactorily. The plantings should be visually inspected annually to look for indications of damage from vandalism, animal damage, and environmental stress such as nutrient or water deficiencies. During dry periods the plants may need irrigation by pumping lake water from a boat mounted pump and hose system. Plantings may also show signs of animal damage. In these cases, the plantings may need to be protected from beavers, muskrats, etc. by fencing or the use of protective tubes over tree and stems.

Additional plantings may be necessary in cases of damage to the plantings by humans, drought, and animals. Most species planted would only need irrigation during dry periods for the first two years. After two years the plants should be sufficiently acclimated to the site conditions.

## **10c. Estimated Periodic Maintenance Schedule for Shoreline Treatments**

### **Periodic Maintenance Schedules**

The treated shoreline areas should be inspected for shifting, movement, or damage at least once per year or with each lake level draw down.

## **10d. Maintenance Strategies and Contracting**

The Owner may elect to contract out the annual inspection of the shoreline, especially if the lake manager's schedule does not include winter responsibilities.

A contracted inspector should have the experience and qualifications to be able to read the original construction plans, understand the objectives of the shoreline stabilization project, discern shifting and damage to the revetment and plants. The contractor should have the equipment (boat, camera, tools, etc.) to perform the duties.

The inspector/maintenance contractor should have adequate tools to effectively maintain the revetment and plantings such as: large stone moving bars, chain saw, utility boat with adequate horsepower, watering spraying equipment (for irrigating plantings during dry season), and erosion control blanket and erosion control seed mixes as required.

**10f. Estimated O & M Costs per Year**

The annual contractual inspection and maintenance of shoreline treatments costs are estimated to be in the following range:

Mobilization .....	\$20 - 50
Inspection time, photography, and reporting .....	\$600 - 1,200
Maintenance services .....	\$600 - 1,200
<b>Estimated Total .....</b>	<b>\$1,220 - 2,450</b>

Other costs may be incurred to replace damaged plantings. Typically replaced tree and shrub stakes cost from \$0.65 to \$1.00 each.

For budgeting purposes approximately 3 - 4% inflation should be added to this cost range past 1997.

**10g. POST CONSTRUCTION MONITORING PLAN**

Two approaches can, and should, be taken to the monitoring component of the West Boggs Lake enhancement project.

- 1) Post monitoring of overall lake water quality response.
- 2) Monitoring the effectiveness of a specific management practice, such as the shoreline stabilization treatments.

The 1988 EPA Lake and Reservoir Restoration Guidance Manual has a section on Post monitoring of lake restoration projects. It is suitable for monitoring overall lake water quality improvement resulting from implementation of restoration practices. The Guidance Manual contains a table listing a sampling protocol for overall lake monitoring.

The lake monitoring plan that follows will primarily focus on monitoring the overall lake water quality. A secondary component of the monitoring plan is to inspect the shoreline to monitor the success of shoreline erosion control treatments.

A plan to monitor the success of lake enhancement projects must contain four key elements:

- 1) Qualified personnel to perform the monitoring;
- 2) Clearly defined monitoring objectives with a specific set of monitoring parameters;
- 3) A monitoring schedule;
- 4) A reporting format.

**10h. Qualified Personnel**

Personnel monitoring the success of the project after construction is complete should have the following qualifications:

- General knowledge of aquatic ecosystem functions.
- Familiarity with the design objectives to be achieved by the biotechnical shoreline project.
- Familiarity with identification of aquatic macrophytes (vegetation other than algae), herbaceous vegetation, shrubs and trees.
- General familiarity with the watershed and soil types.

Persons qualified to perform part or all of the monitoring may include:

- Professional environmental scientists such as Commonwealth Biomonitoring staff.

10i. Monitoring Objectives and Recommended Inspection Parameters

The objective of this monitoring program is to ensure that shoreline treatment are performing their functions they were designed to provide. In order to monitor the effectiveness of treatments, a set of monitoring parameters must be defined. The following parameters should be monitored.

1) Condition of the planted community at each treatment:

- identification of the following plant classifications
  - shrubs (woody plants less than 4" diameter)
  - trees

A site map from the engineering design phase of the constructed wetland project can be used as a base map for, monitoring the vegetative communities. A photographic record is also a valuable monitoring tool for documenting the progression of the planted trees and shrubs.

2) Structural inspection:

- Human activity and vandalism, such as removing stones for private use, or tossing the stone into the lake, etc.
- Animal activity, such as beaver or muskrat burrowing, and removal of trees.
- Erosive destabilization
- Establishment of vegetative communities

Illegal activity observed should be promptly reporting to the lake manager or conservation law enforcement personnel to prevent impairing the performance or integrity of the biotechnical shoreline treatment systems.

3. Limnological:

The LLCD is required to maintain a lake water quality monitoring program by the City of Bloomington Utilities who owns Lake Lemon, in a lease agreement with CBU.

The LLCD monitoring program is basically the same monitoring program parameters as the IDEM's Indiana Lake Management Plan Eutrophication Index. This monitoring program should be continued for consistency and the ability to compare water quality trends over time.

10j. Monitoring Schedule

The monitoring should be continue to be performed during the summer stratification period. Eutrophication Index (EI) monitoring results should not be compared between different seasons.

The monitoring program should also be continued throughout the construction period, if construction is performed during summer stratification.

10k. Limitations to the Chosen Parameters

TSS and Secchi depth are the parameters most indicative of the functional success of the shoreline stabilization treatments.

Transparency (Secchi depth) can be affected by either dissolved organics or suspended solids. In the fall the concentration of dissolved organics are very high in surface waters due to the decomposition of vegetative matter. In the summer, algae blooms will limit transparency. The shoreline stabilization treatments are designed to reduce the levels of suspended soil particles in the water column.

10l. Sampling Locations and Sample Collection/Analysis

Secchi depth readings should be taken on windward shorelines at the project site locations, both prior to the construction for the biotechnical shoreline stabilization measures and after construction of the measures to compare the difference in water clarity.

An aquatic science lab, such as Commonwealth Biomonitoring, Inc. (CBI) lab in Indianapolis (phone (317) 887-5855), can be used to perform the field sampling and laboratory analytical chemistry services. CBI will supply sample containers for the collection and storage of water samples to be analyzed.

10m. Reporting Format

The reporting of field measurements and observations should be done on the standard forms presently being used for the existing water quality monitoring program to be able to easily compare trends in water quality measurements. made up by the person designated responsible for the monitoring and reporting of results.

All field data sheets should be copied and stored in a three ring binder for annual compilation and analysis. Results of each monitoring should be tabulated so that comparisons between monitoring inspections are presented in only a few tables.

# **Section 1 1**

**Estimate by bid item**

**CONSTRUCTION COST ESTIMATES PER SHORELINE AREA  
COMMONWEALTH BIOMONITORING, INC.**

#### Division "A" Site 1A

**ication:**

### NorthWest Corner of Lake

### Category 3 Wave Energy Zone

**Rip Rap Mound Toe Protection, Rip Rap Bank Protection With Tree Stakes and Seedlings.**

[illegible]

**CONSTRUCTION COST ESTIMATES PER SHORELINE AREA  
COMMONWEALTH BIOMONITORING, INC.**

#### Division "A" Site 3B

### Category 3 Wave Energy Zone

### Rip Rap Mound Toe Protection, Rip Rap Bank Protection With Tree Stakes and Seedlings.

[illegible]

**CONSTRUCTION COST ESTIMATES PER SHORELINE AREA  
COMMONWEALTH BIOMONITORING, INC.**

#### Division "B" Site 1C Cemetery Island

### Category 3 Wave Energy Zone

**Coir Fiber Logs/Blanket, Bioengineering With Tree Planting**

[illegible]

# **Section 12**

**Applicable environmental permits**

## **Lake Lemon Shoreline Stabilization Project Permitting**

### **Construction Permits Status Summary**

Four permitting agencies were notified for permits or authorization for this project and the summary of the permits' status are presented below.

#### **Permit and Agency**

#### **Status**

U.S. Army Corps of Engineers 404 Permit

Authorization under NW Permit #13 has been received by the COE.

IDEM 401 Water Quality Certification Permit

According to Andrew Peloso of the IDEM, for projects falling under COE NW Permit #13, 401 WQC is not required.

IDNR, Div. of Water Construction in Floodway Permit

According to Indiana law, the IDNR Division of Water does not require Const. In Floodway permits for shoreline work on water supply reservoirs.

Monroe County Planning Department Excavation Permit

The Monroe Co. Planning Department has issued permit authorization based on the receipt of the COE NW Permit #13.

**DEPARTMENT OF THE ARMY**  
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE  
CORPS OF ENGINEERS  
P.O. BOX 59  
LOUISVILLE, KENTUCKY 40201-0059

November 17, 1997

Operations Division  
Regulatory Branch (North)  
ID No. 199701613-bkc

Mr. Robert E. Madden, CLP  
Lake Manager  
Lake Lemon Conservancy District  
P.O. Box 59  
Unionville, Indiana 47468

Dear Mr. Madden:

This is in response to your request for authorization to excavate a trench and place riprap along the shoreline in three areas within Lake Lemon, Sections 27 and 28, Township 10N, Range 1E, in Monroe County, Indiana. These areas are identified as: Site 1A1, northeast of the dam, 185 feet; Site 1C, Cemetery Island, 220 feet; and, Site 3B, northwest area of the lake, 240 feet. The information supplied by you was reviewed to determine whether a Department of the Army (DA) permit will be required under the provisions of Section 404 of the Clean Water Act (CWA).

Your project is considered a discharge of dredged and/or fill material for bank stabilization activities and minor discharges. The project is authorized under the provisions of Nationwide General Permit 33 CFR 330 (13), Bank Stabilization and (18), Minor Discharges, as published in the Federal Register, December 13, 1996. Under the provisions of this authorization, you must comply with the enclosed Terms for Nationwide Permits Nos. 13 and 18, and the Nationwide Permit Conditions.

You may proceed with the work without further contact or verification from us. The enclosed Compliance Certification should be signed and returned when the project is completed. This decision is valid for 2 years from the date of this letter. If your project is not completed within this 2-year period or if your project is modified, you must contact us for another determination. A copy of this letter will be sent to your agent.

If you have any questions, please contact me by writing to the above address, ATTN: CEORL-OP-FN, or by calling (502) 582-5607. Any correspondence on this matter should refer to our ID No. 199701613-bkc.

Sincerely,

**ORIGINAL SIGNED**

Brenda Carter  
Regulatory Specialist  
Regulatory Branch

Enclosures

## **TERMS FOR NATIONWIDE PERMIT NO. 13**

*Bank Stabilization.* Bank stabilization activities necessary for erosion prevention provided the activity meets all of the following criteria:

- a. No material is placed in excess of the minimum needed for erosion protection;
- b. The bank stabilization activity is less than 500 feet in length;
- c. The activity will not exceed an average of one cubic yard per running foot placed along the bank below the plane of the ordinary high water mark or the high tide line;
- d. No material is placed in any special aquatic site, including wetlands;
- e. No material is of the type, or is placed in any location, or in any manner, so as to impair surface water flow into or out of any wetland area;
- f. No material is placed in a manner that will be eroded by normal or expected high flows (properly anchored trees and treetops may be used in low energy areas); and,
- g. The activity is part of a single and complete project.

Bank stabilization activities in excess of 500 feet in length or greater than an average of one cubic yard per running foot may be authorized if the permittee notifies the District Engineer in accordance with the "Notification" general condition and the District Engineer determines the activity complies with the other terms and conditions of the NWP and the adverse environmental effects are minimal both individually and cumulatively. This NWP may not be used for the channelization of a water of the United States. (Sections 10 and 404)

## **TERMS FOR NATIONWIDE PERMIT NO. 18**

*Minor Discharges.* Minor discharges of dredged or fill material into all waters of the United States provided that the activity meets all of the following criteria:

- a. The quantity of discharged material and the volume of excavated area does not exceed 25 cubic yards below the plane of the ordinary high water mark or the high tide line;
- b. The discharge, including any excavated area, will not cause the loss of more than 1/10 acre of a special aquatic site, including wetlands. For the purposes of this NWP, the acreage limitation includes the filled area and excavated area plus special aquatic sites that are adversely affected by flooding and special aquatic sites that are drained so that they would no longer be a water of the United States as a result of the project;
- c. If the discharge, including any excavated area, exceeds 10 cubic yards below the plane of the ordinary high water mark or the high tide line or if the discharge is in a special aquatic site, including wetlands, the permittee notifies the District Engineer in accordance with the "Notification" general condition. For discharges in special aquatic sites, including wetlands, the notification must also include a delineation of affected special aquatic sites, including wetlands (Also see 33 CFR 330.1(e)); and
- d. The discharge, including all attendant features, both temporary and permanent, is part of a single and complete project and is not placed for the purpose of a stream diversion.
- e. This NWP can not be used in conjunction with NWP 26 for any single and complete project. (Sections 10 and 404)



# INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

*We make Indiana a cleaner, healthier place to live*

Frank O'Bannon  
Governor

John M. Hamilton  
Commissioner

December 24, 1997

100 North Senate Avenue  
P.O. Box 6015  
Indianapolis, Indiana 46206-6015  
Telephone 317-232-8603  
Environmental Helpline 1-800-451-6027

**VIA CERTIFIED MAIL P 126 011 393**

Mr. Steve Chafin  
Commonwealth Biomonitoring, Inc.  
7256 Company Drive  
Indianapolis, Indiana 46237

Dear Mr. Chafin:

Re: Section 401 Water Quality Certification  
Notice: 199701613-bkc

This letter is in reference to your correspondence dated November 19, 1997, regarding confirmation that your proposed project does not require an individual Section 401 Water Quality Certification. Specifically, you propose to place fill material along several sites at Lake Lemon in Monroe County at Sections 27 and 28, Township 10N, Range 1E for stabilization. In a letter dated November 17, 1997, the U.S. Army Corps of Engineers authorized this activity under Nationwide General Permit Number 13, Bank Stabilization.

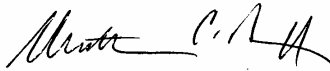
Based on current state and federal regulations, since this activity qualifies for Nationwide Permit 13 you are not required to obtain a site specific Section 401 Water Quality Certification for this project.

On February 8, 1997, the Indiana Department of Environmental Management granted Section 401 Water Quality Certification for a set of Nationwide Permits. This decision is noted in the enclosed reprinted letter. As such IDEM does not require any application for 401 Water Quality review, since any project which qualifies for this Nationwide Permit is considered approved based on the conditions set forth in our letter dated February 8, 1997.

The granting of Section 401 Water Quality Certification does not relieve the applicant from the responsibility of obtaining any other permits or authorizations that may be required for this project or related activities from IDEM or any other agency.

We hope this letter satisfies any concerned parties and addresses all relevant issues. If there are any further questions or concerns, please contact Mr. Andrew Pelloso, Project Manager, at 317/233-2481.

Sincerely,

A handwritten signature in black ink, appearing to read 'Matthew C. Rueff', with a large, stylized flourish extending from the end of the signature.

Matthew C. Rueff  
Assistant Commissioner  
Office of Water Management

Enclosure

### 13. INSPECTION PLAN

#### 13a. Overall Description of Project and Quality Control Plan

##### **Description**

The projects are designed to prevent shoreline erosion of critical areas of the lake through the use of a combination of flexible revetment shrub and tree planting. Some excavation is necessary to reduce some shoreline slopes to an angle of 2h:1v or less.

There are seven primary construction activities in each project area.

- ☐ Improve access to each site (does not apply to Site 1c North Cemetery Island) to prevent damaging existing access roads or property.
- ☐ Erosion control to prevent the movement of sediment into the lake from land disturbing activities.
- ☐ Excavation to make a key way as a footing for the flexible revetment on the lakeshore slope.
- ☐ Installation of geofabric over areas to be treated with rip rap.
- ☐ Planting tree and shrub stakes through the geofabric.
- ☐ Placement of rip rap over geofabric and into key way for flexible revetment.
- ☐ Repair and re vegetate all areas disturbed by construction activity.

Rip-rap with a mean diameter of at least 12 inches must be used in high energy areas for erosion control and to prevent movement of individual stones during high energy wave conditions.

##### **Quality Control Plan**

The Contractor shall provide and maintain an effective quality control program. This program shall establish a means to perform sufficient inspection and tests of conformance to applicable Specifications and Drawings with respect to the materials, workmanship, construction, finish, and functional performance. This control will be established for all construction.

The Contractor shall furnish the Owner/Inspector, within thirty (30) days after receipt of Notice to Proceed, a quality control plan which shall include the procedures, instructions and reports to be used. This document will include as a minimum:

- 1) The Quality Control Organization;
- 2) Authority and Responsibilities of Quality Control Personnel;
- 3) Methods of Quality Control, including that for his subcontractor's work;
- 4) Method of Documenting Quality Control Operation, and Inspection.

## **Authority and Duty of the Inspector**

The Inspector employed by the Owner is stationed on the work to:

- 1) Keep the Owner informed as to the progress of the work and the manner in which it is being performed.
- 2) Report whenever it appears that the materials furnished and the work performed by the Contractor fail to fulfill the requirements of the Specifications and Contract.
- 3) Call to the attention of the Contractor any deviation from or infringements upon the Plans and Specifications.
- 4) Check and verify that the Contractor is keeping and maintaining Project As-Built Drawings (if required by the IDNR Division of Soil Conservation LARE engineer).

Inspectors shall be authorized to inspect all WORK done and materials furnished and to exercise such additional authority as may be delegated to them in writing by the Engineer. Such inspection may extend to all or any part of WORK done and material furnished. They shall have authority to reject defective material and to suspend any WORK that is being done improperly, subject to the final decisions of the Engineer.

Such inspection shall not relieve the Contractor from any obligation to furnish acceptable materials or to perform all WORK strictly in accordance with the requirements of the Plans and Specifications.

Resident Project Inspectors shall not be authorized to revoke, alter, enlarge, relax, or release any requirements of the Specifications, nor to approve or accept any portion of the WORK, nor to issue instructions contrary to the Plans and Specifications. They shall, in no case act as foremen or perform other duties for the Contractor nor interfere with the management of the WORK by the latter. Any advice which Inspectors may give the Contractor shall in no way be construed as binding the Engineer or the Owner in any way, or releasing the Contractor from the fulfillment of the terms of the Contract.

The Owner, the Engineer, and his authorized Inspectors will at all times have access to the WORK, to determine if the WORK is proceeding in accordance with the CONTRACT DOCUMENTS. If in the opinion of the Owner, the Engineer and his authorized Inspectors, the WORK is not proceeding in accordance with the CONTRACT DOCUMENTS, or the Contractor is utilizing undesirable construction practices, the Owner, the Engineer and/or through his authorized representatives, may direct the Contractor to cease WORK and correct all DEFECTIVE WORK and undesirable construction practices. The Contractor will bear all expenses for correcting DEFECTIVE WORK, and will bear any and all monetary losses and expenses relating to and resulting from ceasing of WORK because of DEFECTIVE WORK. Such expenses to also include compensation to the Owner for non-productive inspection expenses during the time lost while corrective DEFECTIVE WORK, the Contractor will not be granted an extension of the Project scheduled completion time.

### **General Inspection of Materials and Workmanship**

All materials used in the construction of the Project shall be subject to adequate inspection in accordance with generally accepted standards, as required and defined in these CONTRACT DOCUMENTS.

The Contractor shall provide at the Contractor's expense the inspection services required by the CONTRACT DOCUMENTS.

If the CONTRACT DOCUMENTS, laws, ordinances, rules, regulations or orders of any public authority having jurisdiction require any WORK to specifically be inspected, testing, or approved by someone other than the Contractor, the Contractor will give the Owner timely notice of readiness. The Contractor will then furnish the Owner the required certificates of inspection, testing or approval.

Inspections, tests, or approvals by the Owner or others shall not relieve the Contractor from the obligations to perform the WORK in accordance with the requirements of the CONTRACT DOCUMENTS.

The Owner and the Owner's representatives will at all times have access to the WORK. In addition, authorized representatives and agents of any participating Federal or State agency shall be permitted to inspect all WORK, materials, payrolls, records or personnel, invoices of materials, and other relevant data and records. The Contractor will provide proper facilities for such access and observation of the WORK and also for any inspection or testing thereof.

If any WORK is covered contrary to the written instructions of the Engineer it must, if requested by the Engineer, be uncovered for the Engineer's observation and replaced at the Contractor's expense.

If the Engineer considers it necessary or advisable that covered WORK be inspected by others, the Contractor, at the Engineer's request, will uncover, expose or otherwise make available for observation, inspection or testing as the Engineer may require, that portion of the WORK in question, furnishing all necessary labor, materials, tool and equipment. If it is found that such WORK is defective, the Contractor will bear all the expenses of such uncovering, exposure, observation, inspection and testing and of satisfactory reconstruction, if, however, such WORK is not found to be defective, the Contractor will be allowed an increase in the Contract price or an extension of the Contract time, or both, directly attributable to such uncovering, exposure, observation, inspection, testing and reconstruction and an appropriate CHANGE ORDER shall be issued.

### **Substitutions**

Whenever a material, article, or piece of equipment is identified on the Drawings or Specifications by reference to brand name or catalog numbers, it shall be understood that this is referenced for the purpose of defining the performance or other salient requirements and that other products of equal capacities, quality and function shall be considered. The Contractor may recommend the substitution of a material, article, or piece of equipment of equal substance and function for those referred to in the CONTRACT DOCUMENTS by reference to brand name or catalog number, and if, in the opinion of the Engineer, such material, article,

or piece of equipment is of equal substance and function to that specified, the Engineer may approve its substitution and use by the Contractor. Any cost differential shall be deductible from the Contract Price and the CONTRACT DOCUMENTS shall be appropriately modified by CHANGE ORDER. The Contractor warrants that if substitutes are approved, no major changes in the function or general design of the Project will result. Incidental changes or extra component parts required to accommodate the substitute will be made by the Contractor without a change in the Contract Price or Contract Time.

13b. Items of Work to be Inspected

Because the Contract is on a unit price basis the Inspector shall need to maintain records of the quantities of all materials used in the project.

Although the Lake Manager will be responsible for lowering the lake pool level to below the construction site elevations, the Contractor may need to perform supplemental dewatering of the sites during construction. It may not be possible to lower the lake to below minimum construction elevations. The contractor and inspector must be prepared to work in wet conditions.

All road surfaces used for equipment and machinery access shall be restored to original condition. No tracked equipment shall be off loaded or driven onto asphalt or other consolidated pavement roadways.

The Owner's representative Inspector shall ensure Contractor compliance with his Quality Control Plan as submitted.

The items of work to be inspected include the following items:

- ☐ No damage from loading and unloading equipment and access beyond the construction easement limits.
- ☐ Horizontal and vertical layout of areas to be treated.
- ☐ Installation of erosion control silt fence (3' non-woven) lakeward of the key trench.
- ☐ Excavation of key trench.
- ☐ Slope (bank) excavation.
- ☐ Installation of geofabric.
- ☐ installation of tree and shrub stake -planting.
- ☐ Installation of rip rap.
- ☐ Planting/seeding and installation of erosion control blanket on slopes above the areas of rip rap treatment.
- ☐ Re-seeding and repair of access roads and construction easements

**Erosion Control**

- Silt fence is to be placed lakeward of the key trench excavation. The silt fence shall be 3' non woven with stakes driven in the lake bottom and the bottom edge of the fabric held down with stones to seal the bottom.

- Geofabric is to be installed where rip-rap is to be placed immediately after excavation.
- Rip rap at least 8 inch  $D_{50}$  is to be placed over the geofabric as soon as is practical to prevent erosion beneath the geofabric.
- Areas above the rip-rap treatment shall be promptly finish graded, fertilized with a high nitrogen/low phosphorus fertilizer (according to a soil test), seeded with the specified seed mixes to the specified rates, and blanketed with the specified erosion control blanket.

13c. Inspector Layout and Staking

The on-site inspector is not responsible for the correct layout and staking of the project. This is the responsibility of the contractor, however, the plans should be consulted for the locations of temporary benchmark(s) (TBMs) at each site to lay out the treatments in relation to the TBMs as depicted on the plans.

13d. Contractor's Maintenance and Development of As Built Drawing

While it is the responsibility of the Contractor to develop and maintain As-Built drawings for each phase of construction, the on-site inspector is required to maintain copies in clear readable order on the project site for the inspection by any interested party.

The Contractor shall keep one (1) copy of all project specifications, plans, addenda, modifications, supplemental drawings, shop drawings and change orders at the project site in good order and annotated to show all changes made during the construction process. In addition, the Contractor and Inspector shall keep one (1) set of "As-Built Drawings" for the project.

These as-built drawings will show all final elevations, all final dimensions, sizes and depths for buried key trenches, limits of rip rap, and all other information as necessary to constitute as-built records. These documents shall be kept daily by the Contractor and be made available to the Inspector and routinely checked by the Inspector for completeness and accuracy based on the Inspector's daily records and notes. It will be the Contractor's responsibility to furnish any and all information lost due to the Inspector's loss of these record drawings and vis-a-vis. In addition to other Contract requirements, retainage will be partially based on the Contractor's and Inspector's ability to maintain good as-built records, as determined by the Owner. Upon completion of the project these record "as-built" drawings together with any other annotated supplemental plans, drawings, sketches, etc. shall be delivered to the Owner for his final review and approval. If approved, the documents will be delivered to the Engineer for the Owner's record. If disapproved, they will be returned to the Contractor for corrections, as necessary.

13e. List of Inspector's Equipment

All persons providing construction inspection services shall have available at all times the following minimum list of equipment:

- ☐ A surveying level, tripod, and measurement rod in good working condition.
- ☐ Fiberglass or steel measuring tapes.
- ☐ Camera with 35mm slide film.
- ☐ Note/journal keeping materials and hand calculator.
- ☐ A four foot level/plumb rule in good operating condition.
- ☐ Materials to develop and maintain As-Built Drawings.
- ☐ Telephone numbers and conversation logs with Owner, Engineer, Contractor, and the IDNR Division of Soil Conservation, LARE Engineer.

13f. Required Qualifications of Inspectors

All persons performing inspection services shall have the following minimum qualifications:

- ☐ Demonstrated experience reading and interpreting construction plans and specifications.
- ☐ Demonstrated expertise/document experience in the establishment of vertical and horizontal control.
- ☐ Experience in the inspection and/or installation of geofabric and rip-rap for erosion control.
- ☐ Experience in the identification and inspection of shrub and tree stake species identification.
- ☐ Knowledge and experience in the application of erosion control products and materials and revegetation seed materials and methods.

### **Designer's Estimate For Inspection Services**

The inspection costs for the Lake Lemon Shoreline Stabilization Project will be dependent on several variable factors. The nine identified sites could go to construction one at a time or two to three sites at once. By working on several sites at once one inspector could cover multiple sites, depending on the speed at which the contractor(s) works. The faster the contractor(s) work the fewer sites that an inspector can cover effectively.

Assuming that the lake level can be maintained below the construction zone at less than the base construction elevations for excavation in "above water conditions" the actual cost for professional inspection services will depend on the following variables:

- ☐ The number of shoreline sites being treated at the same time.
- ☐ The project time length which may be dependent on the ability of the LLCD to maintain water levels at 4' more below the normal pool elevation.
- ☐ The length of time it takes for the contractor to complete the project.

### **Per Diem Rate Schedule For Commonwealth Biomonitoring, Inc. Inspection Staff**

Hourly Rate For Inspection Staff: .....	\$55/hr
Hourly Rate For Senior Inspection Staff: .....	\$65/hr
Mileage: .....	\$0.31/mi. (or IRS allowable)
Subsistence per day (if resident inspector is required to live in hotel): .....	\$75/day

For resident inspection of each shoreline stabilization area the inspection cost estimate is based on the following set of assumptions:

- ☐ A senior staff person will supervise the construction for at least the first area to be constructed by each individual contractor.
- ☐ The daily mileage will be limited to 30 miles per day.
- ☐ The resident inspector will live in Monroe County and not require a subsistence per diem.
- ☐ The construction project period will be 7 days per site.

### **Estimated Inspection Cost Per Site**

Therefore, the Commonwealth Biomonitoring, Inc. estimate for inspection services per site are as follows:

Labor (\$65/hr * 8 hrs/day * 7 days) .....	\$3,640.00
Mileage (\$0.31/mi * 30 Miles/day * 7 days) .....	\$65.10
<u>Subsistence (\$75/day * 0 days) .....</u>	<u>\$0.00</u>
<b>Total Estimated Inspection Cost Per Site .....</b>	<b>\$3,705.10</b>